"I Just Let Him Cry…": Designing Socio-Technical Interventions in Families to Prevent Mental Health Disorders.

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Interventions that help children develop protective factors against mental health disorders are an inherently social endeavour, relying on a number of actors from within the family as well as the school context. Little work thus far in CSCW and HCI has examined the potential of technology to support or enhance such interventions. This paper provides the first steps to unpacking this socio-technical design space, focusing on emotional regulation (ER) as a specific instance of a protective factor. We combine a user-centred approach to understanding lived experiences of families (interviews, design workshops) with an expert-led understanding of what makes interventions psychologically effective. Our findings suggest the potential of technology to enable a shift in how prevention interventions are designed and delivered: empowering children and parents through a new model of 'child-led, situated interventions', where participants learn through actionable support directly within family life, as opposed to didactic in-person workshops and a subsequent 'skills application'. This conceptual model was then instantiated in a technology probe, which was deployed with 14 families. The promising field study findings provide an initial proof-of-concept validation of the proposed approach.

CCS Concepts: • **Human-centered computing → HCI theory, concepts and models**; *Field studies*; *User centered design*; *Collaborative and social computing devices*;

Keywords: Prevention Science; Families; Mental Health Promotion; Emotion Regulation; Social-Emotional Learning; Interventions

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1 INTRODUCTION

Mental health problems represent the largest single cause of disability in the UK, with the cost to the economy is estimated at £105 billion a year — roughly the cost of the entire national health service [92]. Most mental health disorders are chronic and begin early in life (75% before the age of 18 years), and this realisation is fuelling calls by national governments and international organisations for preventative interventions in childhood [99, 104, 152]. Although the psychological mechanisms to develop protective factors against mental health disorders are relatively well understood and evidence-based interventions exist (see [33, 149] for reviews), only little is known about the potential of technology to address some of the critical challenges remaining – including those of access, engagement, and training costs that prevention programs face when trying to reach families of young children [130, 133]. As such, it is not clear if/how technology could be used to facilitate transfer of such learning from school into families (cf. [132]); or to enable new types of interventions that would empower parents and children to further develop protective competencies independently on formal training programs.

This work focuses on *emotional regulation (ER)* as a specific instance of a protective factor. We chose emotion regulation as it is a fundamental life skill, with effects on life outcomes comparable in size to those of IQ or family social status [2, 94]. Research shows that these effects are wide reaching: if ER is poorly developed, it leads to increased chances of developing mental health disorders [3, 12, 49, 78, 91] as well as societal problems such as criminal behaviour [20], low personal wellbeing [94], and academic under-achievement [29].

Our aims are to provide the first steps to unpacking this inherently socio-technical design space, which requires an understanding of research literature across Psychology (what works), HCI (what is technically feasible); as well as insights into the everyday practices of families within the designed for social context (what people actually do). Our methodological approach thus draws on combining a user-centred approach to understanding the lived practices of families within a particular community, with an expert-led understanding of the experiential components that make interventions psychologically effective. To do so, our work proceeded in a number of interrelated phases:

- First, we **interviewed** 15 parents and children from an underprivileged community, which falls into 5% of most deprived areas nationally. Supporting these populations is an urgent issue as prior research repeatedly shows that under-privileged children are particularly at risk of low self-regulation competencies at an early age [29, 52], and the gap further widens over the school years [106]. The goal of the interviews was in gathering 'thick' qualitative data that could drive design: we aimed to develop an understanding of the existing practices used by families, including their beliefs, emotion-regulation support that parents provide their children, and the technologies already in place (or the lack thereof).
- Second, we **combined such empirical data with psychological theories** originating in Educational Psychology and Prevention Science to identify the socio-technical constraints and opportunities of how technology-enabled interventions could fit within the lived worlds of these families.

- As a result, we **proposed two high-level design goals** that embody substantial conceptual shifts in how prevention interventions could be designed and delivered with technology: the notion of 'situated interventions' and 'child-led rather than parent driven' approach.
- Finally, we instantiated these conceptual design goals into a proposed intervention model and designed a **technology probe** to validate some of the core assumptions. We report on it's deployment with 14 families to provide an initial validation of the envisioned approach.

Overall, this paper contributes a set of empirically grounded design opportunities that can inspire new models of prevention interventions; as well as an initial case study exploration within an under-researched area. We discuss the novel directions this opens and hope this work might serve as an inspiration and a bridge between Prevention Science and CSCW communities.

2 RELATED WORK

This work spans multiple fields that are not commonly connected: We will start with an overview of existing work on parent-child interaction in CSCW/HCI and technology-enabled learning. We then switch to the psychology strand to outline the increasing importance of prevention and promotion interventions, overview the existing research into impacts of (mal-) adaptive emotion regulation strategies, and highlight the known challenges within existing interventions.

2.1 Related work in HCI

2.1.1 Parent-child interaction and interventions in CSCW and HCI. Although a growing body of work suggests that technology-enabled tools could effectively scaffold parent-child activities, most so far has been focused on supporting remote parent-child communication. For example, a number of projects have explored how technology-enabled systems can provide a virtual space where parents and children can interact [71, 138, 155]; or support parent-child activities when the parent and child are at remote locations, such as facilitating gameplay [39, 57] or reading together [113]. With regards to research aiming at supporting parent-child interactions in co-located contexts, recent work has explored multi-touch tabletop applications (see [154] for a review); sensor-based co-operative exergames [122]; and technology-enhanced storytelling activities [23, 139].

Other research has explored opportunities for technology to not only support parents, but also provide intervention. For example, TalkBetter [58] and TalkLIME [135] are in-situ mobile intervention services that have been specifically targeted at supporting interactions between parents and children with delayed language development by providing real-time feedback to parents during their ongoing conversation with their child. TOBY [145] helps parents start early intervention for their children with autism to improve their child's competencies such as attention, memory, and recognition. Pina et al. [111] have designed a system to help parents who have children with Attention-Deficit/Hyperactivity Disorder (ADHD) by detecting parental stress and offering in situ cues that remind parents of behavioural strategies to practice in those moments of duress. Geared towards all preschool children, smartphone-based system WAKEY [22] helps parents use better communication strategies to teach their children to carry out their morning routines.

However, research around the potential of digital technology to support the development of social-emotional competencies at home for typically developing children has been limited in the HCI community [130, 133]. The few recent relevant projects include the design of an interactive artifact created to support social-emotional learning in children aged 3-6 years [137], and the development of an intelligent social tutoring system (ISTS) designed to assess and build prosocial skills for children aged 7-12 years [26]. Finally, Slovak et al explored mechanisms to engage parents with social-emotional learning content at home through an interactive, game-like activity [132].

2.1.2 Emotion regulation and technology. Similarly, only a limited body of work is available that would focus on technology-enabled emotion regulation support. The closest are emerging systems that use game-based bio-feedback interventions to support children in improving attention and/or anxiety regulation, often through breathing and relaxation exercises. For example, 'The Journey to Wild Divine' [4] is a biofeedback video game system which has shown potential in teaching relaxation techniques to children with ADHD to reduce disruptive behaviours. Similarly, an evaluation of an 8-week video game-based bio-feedback intervention that combined relaxation training and practice with psychoeducation [76] showed that the system was successful in reducing symptoms of anxiety and depression in a group of 9- to 17-year-olds, who were presenting with clinically relevant symptoms compared to waiting list controls. More recently, an RCT [124] tested the effect of MindLight, a newly developed neurofeedback video game combining evidence-based clinical techniques for reducing anxiety with game design principles aimed to optimise emotional intensity, motivation and engagement, on children with elevated anxiety levels. Finally, MindFull [5] is a mindfulness-oriented, neurofeedback-based, mobile brain-computer system developed to help teach children living in poverty to self-regulate anxiety and attention, with promising results after a 6-week field intervention [6]. Such emerging projects show the potential of technology in extending and scaling up the established bio-feedback techniques in support of self-regulation of attention. However, these focus only on a limited subset of emotion-regulatory competencies covered by the prevention programs, as described in the next section (cf. 2.2).

Another related area of work is focused on 'social assistive robots', with the aim to replicate the diverse emotional benefits that companion animals offer people [14, 100, 105, 136]. Much of the work in SAR interventions has focused on older adults, reporting positive effects on mood, social behaviours and physiological indicators of stress after interactions with Paro in the elderly, particularly those suffering from dementia [60, 87, 96, 118, 147]. Regarding the use of SAR with typically developing children, most research is focused on their use for educational interventions: for example, teaching nutrition to 1st-grade children [129], facilitating English language learning [156], and teaching children to play chess [80]. Despite the reported promising outcomes of SAR interventions in other contexts, there are no studies exploring the use of SARs for supporting emotion regulation competence (or in-the-moment soothing) with typically developing children.

2.1.3 Technology-enabled situated and embodied learning. Situated learning, including peripheral learning, has emerged in the learning sciences as an important strategy (e.g., [44, 54, 55, 85, 88, 108]). There has been an accompanying focus on tangibles and other ways technologies become embedded and used in the learners' environment as a way to accomplish this (see e.g., [7, 34, 56, 86, 112] for reviews and proposed frameworks). As an example of these approaches, tangible and mobile interfaces enabled situated learning in nature [119], museums [82], as well as engaging with computation in classrooms [1, 67]. Such possibility space for the design of situated, embodied learning is moreover steadily expanding with the emergence of conductive fabrics, soft and stretch sensors, and the increasing power and decreasing size of on-board computational capabilities (e.g., [93, 144, 146]). In summary, the existing HCI/CSCW literature provides a wealth of examples showing the technology-enabled opportunity for situated learning and interventions in schools and family spaces; as well as novel technologies that open opportunities for feasible large-scale deployments. However, to best of our knowledge, such developments have not been explored within mental health promotion/intervention contexts and it is not clear if/how these would be applicable.

2.2 Emotional regulation: impact and strategies

An individual's emotion regulation practices can become a protective or a risk factor for the development of mental health disorders. Well-developed emotion regulation is associated with

good health outcomes, and improved relationships and academic and work performance [17, 66]. Conversely, difficulties with emotion regulation are associated with mental disorders [12, 49, 78, 91] and incorporated into several models of specific psychopathologies, including borderline personality disorder [81, 84], major depressive disorder [102, 121], and many others ([41, 68, 91]).

In particular, most theoretical models distinguish maladaptive (risk factors for psychopathology) and adaptive (protective against psychopathology) emotion regulation strategies. For example, Aldao et al review [3] on ER strategies across psychopathology emphasises reappraisal, problem solving, and acceptance as adaptive; while suppression (including both expressive suppression and thought suppression), avoidance (including both experiential avoidance and behavioural avoidance), and rumination are seen as maladaptive. With the exception of problem solving, the maladaptive strategies were found to be more strongly related to psychopathology than the adaptive strategies, indicating that presence of a maladaptive ER strategy might have more adverse effects than the relative absence of particularly adaptive ER strategies.

2.2.1 Deprivation as a key risk factor to low self-regulation. Living in under-privileged conditions, such as in poverty, is a key risk factor for low self-regulation both in childhood and later in life [29, 52]. Already by kindergarten age, children from low socioeconomic status (SES) families are behind in self-control skills relative to middle-class peers [101], and fall progressively further behind over the school years [106, 126]. Given the strong effects of self-regulation on a variety of life outcomes (cf., [94]), such early-age differences in abilities can reinforce the accomplishment gap between middle and low-SES children, and facilitate a negative family spiral of staying in poverty across multiple generations [20]. While low self-regulation in childhood is a strong risk-factor for a number of negative outcomes, it does not necessarily map out the child's life course.

2.2.2 'Universal' prevention interventions. A body of literature in Educational psychology and Prevention Science shows that emotional-regulation—as well as other social-emotional competencies—are malleable: there are evidence-based interventions that can change people's ability to regulate their emotions (e.g., [29, 150, 153]). Moreover, even small improvements in self-regulation in early years can lead to large positive differences in individual life outcomes for both at-risk and general populations [94], with accumulating impacts at the societal level [10].

This has led to a research focus on *universal prevention programs* which are deployed to whole populations (e.g., as whole school approaches) to promote and reinforce personal strengths, rather than being targeted to children already manifesting problems (see e.g., [33] for a review). Drawing on these techniques, a number of prevention programs have been designed and deployed with promising results in Randomised Control Trials (RCTs), showing long-term positive effects over decades [33]. As one example, the Perry Program focused on low-SES populations and found that the program group had only a third of the incarceration rates in comparison with a control group (6% vs. 17%), as well as substantially higher earnings, more stable family relationships, and better health 40 years after the intervention [10, 98].

2.2.3 Existing challenges. While effective, the existing prevention programs are however very resource intensive. The key challenge is that they *lack scaleable techniques to get beyond classroom-based learning and support the in-the-moment reinforcement and scaffolding of the learnt self-regulation techniques*, which are needed for the skills to be transferred from intervention to practice [8, 38, 70, 109, 153]. This is because emotional regulation—and social-emotional skills more broadly—need to be developed for 'hot' moments, i.e., situations when the learner is overwhelmed with emotions; and when the capacity for conscious, analytical thought is diminished [79, 153]. Developing emotional regulation thus requires repeated practice and students' scaffolded experiential learning within relevant situations to ingrain the learning beyond full cognitive control. This is

analogous to how showing someone 'how to ride a bike' will not be helpful unless they can (repeatedly) try it out for themselves. Consequently, *learners need extensive examples and opportunities for personal experience and practice in real-world settings* that are coupled with in-the-moment feedback that drives active reflection on progress [70].

The critical role of providing this scaffolding and support is currently left to teachers and parents, requiring extensive training to do effectively: For example, a shortened version of the Incredible Years program [115, 150] still required 12-24 weeks of parent training in groups of 6-10 parents for 2.5 hours, once a week. The Perry Pre-school program was even more intensive, comprising a 2-year program of 2.5 hours of interactive academic instruction daily coupled with 1.5-hour weekly home visits by trained staff [10]. The need for such in-person training is a substantial barrier in terms of program cost, but more importantly also in the pragmatics of deployment. This particularly affects parents from high-risk communities, such as those with low-SES, who often do not have childcare available, work multiple jobs etc. [109]. So although the extensive programs have been shown to be economically cost effective despite the substantial investment in time, effort, and money [10, 53], the front-loaded costs and time-requirements for parents/teachers substantially limit the scale and impact these programs could have. Here we see the potential for our proposed socio-technical prevention interventions to supplement the work of such programs.

3 METHODS

Methodologically, this work is deeply grounded in the socio-technical tradition as *"an approach to design that considers human, social and organisational factors, as well as technical factors in the design of organisational systems [9]"*. While this tradition might be more deeply steeped in the context of work settings (within CSCW and more broadly), we argue that the principal need to view *"technical features of the system and social features of the work as fundamentally interrelated [97]"* is as important within the context of at-home mental-health interventions.

In fact, such interdependence of social and technical is particularly pronounced in the mental health context: the goal of the designed system is not 'just' in augmenting an existing social practice; the purpose of a mental health intervention is to, ultimately, enable people to change and re-shape some of the deepest ways in which they relate with the world and with one another. Within the selected case study of emotion regulation, the 'work to be supported' are then the intra- and inter-personal practices through which the child perceives, reacts to, and copes with strong emotions. The principles of socio-technical design then apply on multiple levels: how the (technology-enabled) intervention becomes embedded into the current practices of an individual or the family unit; which mechanisms are assumed to lead to shift of these practices; and on which timescales and through which 'levers' this happens in the family context.

It was important for the design process to therefore draw on the understanding of the existing everyday practices of the specific user group, while contrasting such case study data with what is already known in the literature (mental health interventions, prevention science, parenting) as well as the feasibility of technologies. The rest of the section outlines the three-stage process we took in this work: Phase 1 drew on interviews to gather 'thick' qualitative data to ground design process; Phase 2 combined interviews, related work (parenting, intervention literature, technology feasibility) into a conceptual framework; and Phase 3 provided first steps towards validating this conceptual vision and its feasibility.

Ethical approval. The research protocol for all phases of the study was approved by the university's Research Ethics Committee and informed consent/assent was obtained from all individual participants.

3.1 Phase 1: Interviews

We conducted a series of interviews with parents and children from an underprivileged community in the UK, to better understand the existing practices and beliefs about self-regulation of the families in this community, as well as the challenges they face. Such 'thick' descriptions of the everyday practices in the case study community served predominantly as grounding the design process in Section 5, allowing us to combine this understanding of lived practice with SEL theories to identify opportunities for technology-enabled interventions, as well as gain an initial understanding of how such interventions could fit within the everyday lives of these families.

Participants. We recruited parents and children from an underprivileged community, which falls into 5% of most deprived areas nationally. The community was selected as the most impoverished area within Oxford, UK (based on government data). Overall, we interviewed 15 parents who had children within the targeted age-range (6-10 years old) and, where possible, included the children within the interviews (10 children total). This range was selected to mimic the existing SEL programs, predominantly targeting primary school grades. Children's average age was 8.4 years, with more girls (66.7%) than boys (33.3%). The interviews were complemented with participatory observation by the first author, who volunteered weekly at a local youth club for a period of 6 months, alternating between supporting existing activities (e.g., football) and bringing in new ones in collaboration with the youth club team (e.g., mindfulness). The main aim was to understand the community a little better and develop long-term relationships and trust with the community leaders. The interviews were conducted within the first 6 weeks of these engagements (initial 5 by the primary researcher prior to any participatory engagements; the remaining 10 by a research assistant living in the community, who was recruited for this purpose.)

Interview topics. The themes covered in the semi-structured interview included: (i) the existing practices used by families to communicate around self-regulation in this community; (ii) the underlying beliefs, motivation, and perceived challenges to self-regulation; (iii) the support that parents provide their children around self-regulatory competencies more broadly; and (iv) the technologies already in place (or the lack thereof). The interviews sessions (approx 1 hour) were conducted in person, often in participants' homes. Most of the interviews were collected by a research assistant who lived in the area and was trusted by participants as a member of their community, thus having access to their homes.

Analysis process. Each interview was audio recorded, fully transcribed, and then included into a thematic analysis following the process outlined in [19]. The second author transcribed the interviews, and read and re-read the transcripts to familiarise herself with the data. Following this, initial codes were generated across the data set. Different codes were then sorted into potential themes, and all the relevant coded data extracts within the identified themes were collated. At that stage, the first and second author worked together to review and refine the initial themes both at the level of the coded extracts, as well as in relation to the entire data set. Themes were then refined, generating an initial thematic map of the analysis with the resulting main themes and sub-themes. This process was followed to ascertain that the generated thematic map and individual themes accurately represented the data, and that the collated extracts for each theme formed a coherent and consistent pattern across the data set. The refinement of the thematic map and individual themes involved several iterations, until consensus was reached among both authors that the analysis told a coherent, well-organised story about the data. To protect anonymity, participants are referred to by using P for parents and C for children, followed by a participant number.

3.2 Phase 2: Design mechanisms articulation

In order to develop appropriate design mechanisms to support children in developing emotion-regulation skills, as well as to support parents in scaffolding these skills, we engaged in a multi-step, iterative process. We began with the literature review outlined in the Related Work section, to help define the problem space and forge an understanding of prior technological interventions and their contexts. This helped us to prepare the interviews with parents and children concerning their current self-regulation practices. The team drew upon extant psychological theories and best-practice interventions, along with the interview data, to brainstorm potential novel technological support of in-home efforts at rehearsing and discussing self regulation. These ideas were tempered by our knowledge of the technological feasibility of any given concept. This process led us to the articulation of the overarching design goals (discussed in Section 5.1); envisioning of an intervention that instantiates these goals (Section 5.2), as well as the creation of a technology probe validating initial key assumptions (Section 5.3-5.5).

3.3 Phase 3: Technology probe deployment

This last phase reports on a initial deployment of the technology probe, based on the design goals articulated in Phase 2. The probe development was grounded in an 8 months iterative process, including weekly meetings with SEL experts and a series of 9 co-design workshops with parents/children. Due to space constrains, the design process will be reported in a separate paper and here we focus only on describing the final prototypes. We deployed these to 14 families (for a period of 2-4 days) to explore how such a proof-of-concept instantiation of the design goals would be appropriated in real-world settings. Within such short time-scale, the goal was to examine the feasibility of the core design assumptions and explore the nascent design space, rather than evaluate the specifics of the artifact design or formally evaluate the psychological effectiveness of the probe. Section 5.4 will outline the details of the research process and methodology.

4 UNDERSTANDING EXISTING FAMILY PRACTICES

This section presents a qualitative description of the current practices that parents from our case study community reported to use with their children. We start with describing the parental practices as the general backdrop of family self-regulation norms, then move to children's own strategies, and finally articulate the beliefs that appeared to underlie such behaviours; while contrasting the findings with parenting literature. Such detailed description of existing lived experiences and practices around emotion regulation will then serve—together with technological feasibility and existing prevention science mechanisms—as the basis for the design process aiming to identify novel socio-technical interventions in Section 5.

4.1 Existing parental practices

Overall, our interviews highlighted the limited strategies employed by parents to help their children calm down. There was a strong notion of parents expecting children to calm down on their own, but not necessarily providing them with support to do so. We highlight these patterns across the practices parents mentioned when talking about their children, as well as their own self-regulation strategies.

4.1.1 Parental practices to calm down their children. In most instances of conflict, the parental focus was predominantly behaviour-oriented, with parents frequently using external threats and direct demands to the children to change their behaviour. A commonly reported practice was using threats to withdraw children's privileges, such as access to digital technologies or family outings, unless the child 'calms down'. This was often complemented by making sure the child disengages

from the situation at hand. The four quotes below illustrate some of these approaches, as well as highlight how rarely parents brought the emotion or even the underlying need for why the children were 'misbehaving' as a point of discussion; focusing predominantly on cessation of the negative feelings in parents' vicinity.

> "[W]hen they are not doing as they are being told or when they are not very happy with things, I take them away from what they were doing and I tell them they have to sit in their room for a few minutes until they are ready to listen to me." [P18]
>
> "Well, whoever's in a strop or anyone throws a tantrum or whatsoever, we tell them to walk out the room or we let them have their own space." [P15]
>
> "[H]ers depend on if she's being angry or fighting or something and I know she's not calm, I'll be like 'You've got 5 minutes in the room', or if she carries on being stroppy, I'll be like 'OK, now it's 10 minutes in your room'. So, it kind of keeps going up, so if she calms down then I just stick to 10." [P23]
>
> "I'd let him know 'you're crossing your boundaries and your mother and you need to calm down and watch out how you behave and talk'. [...] I have to tell him 'If you're gonna misbehave, I will ban you from his toys or TV-time or [. . .] he'd have to go to bed earlier or on the weekend or on the weekend he won't be allowed to go to his cousins' house. That usually works." [P24]

For nearly a third of the parents, the expectation of child self-soothing capabilities led to assume that 'having a cry' is a normal feature of the children's calming down process. For these parents, it is a natural part of their children's routine when they needed to calm down. For example, P14 mentioned that *"I let him cry. 'You've done wrong, you know, cos you should have let me finish talking and then I would have talked to you'. [...] I let him cry for 10 to 15 minutes, max I'll say 20."*. Similarly, the experience of P21 with her daughter was that *"She will slam the door, she'll let off her steam in her own way. Probably have a little sob."*

Across all of these approaches, the underlying notion seemed to be that children *"[need something to] calm down. And keep them busy. (P13)"* As such, any threats never included removing access to non-digital objects which parents knew their children used to calm themselves down, such as dolls, toys, books or drawing materials. A minority of parents (4/15) also mentioned pro-actively suggesting an distracting activity known to help to defuse a potentially emotional situation. For example, Parent 15 said: *"[I]f I know they get into a spot where they're just gonna burst and that's it [...] I'll tell them from the start 'Why don't you go upstairs and sit and play with you fidget spinner'. I'll give them something to do or what they like doing. Because I know when he plays with the fidget spinner it calms him down."*.

Parent-child conflicts—which were the most commonly reported situations by parents—often seemed to turned into power struggles and the strategies the parents described focused predominantly on behaviour rather than underlying emotions. In contrast, in cases where parents were not involved in the situation which had upset the child, they were more likely to use emotionally supportive strategies. These included encouraging their child to express their emotions, cuddling them, reassuring them, engaging in an activity together, or just being with the child.

> "[When he's feeling upset] I have to get down to what's making him feel this way, so. . . He does tell me and I do try to find a way to get him out of that place where he'd rather be a little bit happy than being upset or angry." [P23]

While almost every parent mentioned talking to their children in situations where they needed to calm down, this was mostly the case after the child had already calmed down on their own and the focus was on addressing the child's misbehaviour and on reiterating rules, rather than discussing their feelings. Parent P17 has for example explained that:

> "Obviously, [with] the older one, I always have to come back and explain it to her. Because she's a lot older and once I've explained my side of it, 9 times out of 10 she will understand. [...]

> Obviously, at the time she'll have a bit of a strop 'Oh, it's not fair' and this, but later when I've come back and calmed down and stuff, the situation's calmed down, she is able to understand." [P17]

Overall, the practices described above are strikingly similar to those employed by parents characterised by 'emotion dismissing' parenting approach. As Gottman et. al. [47] observed, these *"parents felt that the child's sadness or anger were potentially harmful to the child, that it was the parents' job to change these toxic negative emotions as quickly as possible, that the child needed to realise that these negative emotions would not last and were not very important, and that it was the parent's job to convey to the child a sense that he or she could ride out these negative emotions without damage."* Emotion dismissing parents were further characterised as often using distraction when their child was sad, and did not view the emotion as beneficial or as an opportunity for intimacy or for teaching; they did not articulate their child's emotional experience; and many viewed their child's anger (even without mis-behaviour) as enough cause for punishment or a time out [48].

Such commonality in approaches suggests that albeit each family might have their specific practices that will be important for appropriation of interventions (such as what punishment is used), the underlying broader patterns described by our participants are far from unique. This strengthens the possibility that interventions designed with this particular case study group could be, theoretically, transferable to other parenting communities as well.

4.1.2 Parents' own self-regulation strategies. The patterns observed in parental practices aimed at calming down their children fit well with those employed by parents to calm down themselves, with disengagement and distraction being the main two strategies. Again, these results are in line with prior psychological literature on commonly used emotion regulation strategies – cf., Section 4.4 and [3, 51, 127].

Similarly to what was expected of children, parents' preferred strategy was to 'take some time out', either by sending their children off to their room or by removing themselves from the situation. This was described by some mothers as a necessary period to regroup before re-engaging with their children. Their reports overwhelmingly suggest a need to put some distance between themselves and their children when emotions run high. This appears to provide them with the mental space needed to manage their emotions and reflect on the situation. For example, P18 described it as *"if they're [...] getting on my nerves and saying too much, I'll be like, you know, 'I've told you enough times and now get on with what you need to do and don't follow me', I'll shut the door, I'll go to the kitchen and I'll do everything I need to do."*

After disengaging from the situation, most parents' preferred strategy to regulate their affect was to distract themselves with another activity, such as listening to music, watching television or tending to their chores. Parent P20 summarised it as *"I think I used to just put in my Walkman, I'd put in my headset, put YouTube on, put some songs on [...] or anything. Just plug something into my ear and just listen to that and kind of zone everything outside and carry on with my work or whatever or housework."* Although the specific behaviours differed across parents, the core behaviour of distracting oneself and disengaging from the emotional situation seemed constants. The following quote further illustrates the common patterns we observed:

> "Me, usually I probably just go on Instagram, find some funny post that gets me laughing or maybe go through my Snapchat or just to calm down sometimes go for a little drive, maybe get out.....Me-time. Get myself away." [P24]

Finally, a minority sought support from their family in situations where they were overrun by emotions. This practice mostly served as an emotional release for the parents, rather than help them resolve the situation which caused their emotional turmoil:

> "Well, when I need to calm down, I just talk, I talk a lot I think. I talk and I'll just go into my phone, I'll put something on or I'll just ring one of my sisters and I'll talk to them about it.Cos we are a big family we all are always there for each other. So, we're always on the phone anyway. We just talk about what's happening and I think it kinda calms you down, yeah." [P23]

It is worth nothing that a number of parents explicitly expressed their interest in more effective ways of calming themselves down and managing their emotions, especially in situations of conflict with their children. In Parent 13's words: *"I think I can cope with children, but who's gonna calm me down sometimes?"*

4.2 Children's self-regulation strategies

Consistent with the parental approaches, the children we spoke with relied heavily on leaving the scene and engaging in distracting activities as a means of regulating their affect. Two types of children's self-soothing practices were identified, ordered here by the extent to which children would avoid their emotions rather than work with them: (i) avoidant strategies; and (ii) passive/active emotional release. In this section, we describe these practices in more detail.

4.2.1 Avoidant strategies: disengage and distract. A combination of disengagement from the situation and subsequent distraction were predominant. The children would often first *disengage* from the situation and isolate themselves in a calm space. Usually this was imposed to them by their parents or—less frequently—it was the child's own choice. Most children mentioned that they have a particular space in their house where they go when they need to calm down, which in most cases was their room. For instance, when asked what he does when he is feeling frustrated or angry, Child 21 said:

> "I go to my room or to the bathroom [and] I sit behind the door." [C21]

The *distraction* tactics were the second common set of strategies. In most cases, engaging in distracting activities could be construed as the child's conscious effort to avoid thinking about the emotionally challenging situation or dealing with negative affect:

> "I watch Youtube, cos when I'm angry [...] I don't really like thinking. So, I just watch Youtube." [C17]

We identified three predominant distracting activities, listed below in order of how frequently they were reported: First, the children turned to their **teddy bears or dolls** when they needed to calm down. Especially in instances of parent-child conflict, these objects seemed to provide them with the comfort that they needed, but could not seek from their parents at the time. For instance,

> "I go to my room and I squeeze my teddies and toys and my soft pillow that my mum bought me for the bunk bed [...] I squeeze them, like I squeeze them so hard." [C23]

Second, many children **used technology** as a way of calming down, whether that was playing on their tablets or game consoles. At the same time, these devices often also became the catalyst for a parent-child conflict. Therefore, restricting or prohibiting their use of gadgets was often parents' preferred form of discipline, with some mentioning that they favoured a more physical release of emotion by their children, such as playing outdoors. These preferences again did not seem to be based in how well one or another activity supports child's emotional regulation, but rather in their perception of how 'good' these actions were for the children:

> "If she's acting up or having a meltdown or a moment or... You know, it's usually over something technology related. So, I just tell her she can't watch TV or take her tablet off of her. Or if she's got a phone in her hands, whoever's phone it is, that's gone." [P19]

> "I don't give them like whole day Playstation, whole day laptops. No. They're not allowed it like that because it's not good for them. I want them out in the garden playing. Little bit time for every single thing. Maybe they don't have much time to get angry." [P13]

Finally, **engaging in arts and crafts activities**, such as drawing or making jewellery, and reading were two more frequently used methods of distraction. These activities were more positively viewed by parents who often encouraged them, as they felt they were a good way to 'keep them busy':

> "She gets kind of stubborn very quickly. And she's fidgety as well, like out of the three of them she's the most fidgety, [...] so it's harder to kind of calm her down or speak to her or whatever. But once she's gone upstairs, she's read her book or she's done some sort of an activity [...] then she comes out, she's kind of calm, she's ready to watch TV." [P20]

4.2.2 Emotional release. Especially in cases of parent-child conflict where parents were most likely to adopt a more disciplinary approach rather than encouraging their children to express their emotions, some children resorted to crying in their room to release their feelings and calm themselves down. Externalising behaviours, such as becoming verbally or physically aggressive, were much less common and often mixed in with distraction:

> "I just sit in my room for long and then until I come down and say 'I'm sorry to everyone' [...] And I sometimes cry in my bed." [C18]

> "Well, what I do if I'm angry? Ummm... The person that annoys me I'd hit them. Or I'd just go to the TV and watch it. Or... I might just forget about it and play with my Pokémon cards. So, that's one for anger and... sadness. So, if I'm sad I'd just play with my Pokémon cards. Cos there's lots of answers for my Pokémon cards..." [C24]

In addition, a third of the children (5/15) resorted to writing in diaries or drawing as a means of expressing and dealing with their feelings when encountering emotionally challenging situations; and this mostly with girls.

4.2.3 Comparison with existing parenting literature. These findings are generally consistent with previous research on parental socialisation of emotion and serve to instantiate ways in which parents directly socialise children's emotion-related reactions [35, 95]. Specifically, children of parents who are warm, responsive and supportive have been found to use more engagement and fewer disengagement strategies (e.g., more positive cognitions [43], more problem-solving strategies [90], and less suppression [65]) and may use their parents as resources of informational, emotional, or instrumental support, and be more likely to approach them during emotion-laden situations [140]. On the other hand, the predominantly dismissing parental responses we observed in our sample have been shown to penalise children's negative emotions and discourage their expression. Such experiences can communicate the message that emotions are unacceptable and should be suppressed, and thus partly explain the use of disengagement strategies by children in our sample (see also [36, 37] for examples from other studies).

4.3 Underlying beliefs

Overall, our findings suggest that the existing scaffolding of children's self-regulation competencies is limited and parental strategies are mostly geared towards modifying children's behaviour rather than encouraging resolving of the emotions. In this section, we attempt to articulate the beliefs that—in our interpretation—seemed to underlie the parental approaches to emotion regulation (cf., Gottman et al's 'parental meta emotion-philosophy' [47]).

4.3.1 Emotions are transient. The parental interviews suggest that they view emotions as transient; as something that will pass and does not always need to be talked about or worked with. Thus, parental emotion regulation strategies often relied heavily on shifting the attentional focus by distracting themselves or by directing their children to other activities, rather than focusing on their emotional experience. In a particularly pronounced version of this approach, Parent 13

mentioned that she preferred to bottle up her feelings and '*keep quiet*' in order to avoid aggravating the situation by potentially engaging in a conflict with her child.

> "I was burning inside. Because I warned him like he's gonna fall on the floor and that's what happened. But still, I kept quiet, I didn't say anything and that's why he didn't get upset, I'm alright as well. [...] Maybe I get more angry inside but then things become better so I become alright as well." [P13]

Other parents mentioned that their children 'just forget' about the source of their upset after taking some time out to calm down, and a few reported that they 'ignore' or 'forget about' the conflict and their child's feelings and, therefore, do not address them afterwards:

> "Sometimes if I remember I'll go talk to her, I'll be honest. Other times I don't even remember 'Oh my god, yeah, she had this and should I even talk to her'." [P20]

4.3.2 Expectation of self-soothing. Second, the interviews suggest that there is a strong notion among parents that children should be able to self-soothe without immediate support from them. This could perhaps be explained by some parents' view of children's outbursts as attention-seeking attempts, leading them to reject their children's external behaviour and not encourage the expression of negative emotions to avoid reinforcing these mis-behaviours: *"I know each of them... just need a bit of space and then they're right as rain [...] cos they're doing it for attention most of the time [P16]"*. Another possible motivation for letting children calm down on their own could be parents' fear that attempting to intervene when they are already in a state of negative emotional arousal might lead to further conflict, as Parent 14 shared:

> "He knows I let him cry, so I know when he's crying - there's no point disturbing him when he's crying cos it's just gonna get worse. He's just gonna get loud and everything and obviously as a parent you get angry as well cos why your kids are getting loud to you." [P14]

4.3.3 Calming down as a key life skill. At the same time, most parents considered the ability to calm down as an essential life skill for their children.

> "[I]t kind of moulds what they become. And it's not just about now, it's what they become later. They have to learn to manage their feelings and handle them before they get,you know, go out of order or they have an outbreak." [P21]

> "I think it is, because…it's just, ehm, necessary. You can't carry on your day until you are back to being calm. Otherwise the rest of your day, the rest of the child's day would be in that mood…In a dark place. And that would have an effect on you and the child,on the long term. Psychologically, emotionally, behaviour, like, their literal behaviour…." [P24]

Parents also often highlighted how important calming down is for them, being constantly bombarded by emotional situations. The quotes below provide some illustrations of how parents expressed these needs.

> "That is important because obviously if you're not calm, it's like you're just bubbling up, up, up. It's that glass half-full business. So, you're gonna topple over and just be like, you know, all over the place. So, for me it's important to calm down before I feel like I'm having a meltdown sort of thing. [...] I've just got myself together and my son's decided to go, I don't know, empty out all my kitchen drawers, I'm a bit more calm, so I can deal with that rather than if I'm already at boiling point." [P16]

> "I mean if you don't [calm down], then it just escalates more and more. And nobody really gets anywhere. So, I think definitely calming down and dealing with the situation when it's calmer. …It is good to have strategies and things like that to calm down." [P17]

Finally, the interviews suggest that parents were not always successful in recognising signs that their children needed to calm down early enough, resulting in them often trying to calm them down during already ongoing tantrums.

4.4 Comparing interview data with psychology theories

The primary aim of the interview data is to develop a strong qualitative basis for the design process. However, contrasting the empirical findings with other bodies of literature can help unpack the expected impacts of the parenting practices that we saw on emotion regulation. Specifically, we highlight two main challenges with the observed practices from the Prevention Science perspective: first, a mismatch between the strategies used and those considered adaptive in the long-term; second, the specific parenting models where self-soothing was expected and little emotion-regulation support was given. We outline each in turn.

4.4.1 Impact of observed self-regulation strategies. The interview data suggest that the parental support in this community was predominantly oriented towards changing external behaviour rather the underlying emotions. Moreover, the parents believed that their children are—or at least should—be able to self-soothe without their immediate support, with disengagement and distraction as the main two strategies modelled by parents and reported by the children. The resulting practices then meant that children went (or were sent) to a particular location, such as their room, where their remained until they 'calmed down'; often while playing on a tablet/playstation, with their toys, or just 'having a cry'.

In contrast, the key adaptive emotion regulation strategies identified by prior research such as problem solving, acceptance, reappraisal (cf., for example [3, 51] for reviews) are substantially underrepresented in our interview data. As such, these are unlikely to be used by the parents and thus also by the children. In contrast, most of the strategies parents and children did mention are focused on modulating emotional response after it has reached its peak, and are known to be less effective. In particular, some strategies such as avoidance or suppression—that correspond to many of the practices above—are known to be directly mal-adaptive (cf., [18, 65]).

4.4.2 Impact of parenting techniques. The interviews show a lack of emotion focused or problem solving parental engagement, with only a limited direct support for emotion regulation. Previous research has shown that this can be problematic: for example, psychology literature shows that harsh or unsupportive parental responses to children's emotional displays tend to heighten and extend their emotional arousal in emotion-evoking situations and teach them to avoid rather than to explore the meaning of their emotions and ways to appropriately express them [13, 35]. Berlin and Cassidy [13], for example, found that mothers who reported greater control of their preschool children's emotional expressiveness had children who were more likely to suppress their emotions when winning or losing a challenging game. Similarly, in a study of 9 to 12-year-olds it was suggested that maternal punitive and minimising reactions to children's emotions were associated with lower levels of social competence and constructive coping (cognitive restructuring and support seeking) and higher levels of avoidant coping in peer conflict situations [36]. More broadly, studies suggest that parental practices that invalidate, criticise or avoid teaching children about emotions are linked to children's increased likelihood of adopting fewer adaptive emotion regulation strategies and generally poorer emotional adjustment [83, 128], as well as higher likelihood of internalising and externalising behaviour problems [73, 83, 114].

Conversely, research has demonstrated that children whose parents respond in an accepting and supportive manner to their negative emotional displays acquire more constructive ER strategies and can regulate their emotions more adaptively [36, 45, 114]. As one example, Gottman, Katz, and Hooven [47], reported that parental validation of children's negative emotions, and their engagement in coaching their children to identify and cope with their emotions, was related to children's greater capacity to regulate their emotions, which later predicted higher levels of social competence. Others have reported related findings. In addition, children whose parents regularly

discuss emotions with them have been found to demonstrate a more complex understanding of emotion experiences and expression [27, 31, 32], with such understanding of emotional state directly contributing to emotion regulation competency [77].

5 DESIGNING TECHNOLOGY-ENABLED PREVENTION INTERVENTIONS FOR EMOTIONAL REGULATION

The previous parts of the paper touched upon aspects of lived experience (interviews), the adaptive strategies and intervention techniques as identified by prior research (psychology theory), and technology feasibility (related work). Combining these together is needed to identify the design opportunities this space; especially if the aim is to identify novel types of interventions that would not be feasible without the use of technology.

Each of the streams highlights particular facets that would be crucial for successful socio-technical interventions in this space: The *interviews* and parenting literature helped us understand the perceived importance of emotional regulation in everyday lives; the common daily situations where it needs to be put in practice within the families; the associated notion of self-soothing and the reliance on specific location in home where such soothing happens; as well as the dependence on distraction and disengagement as the two key strategies. Similarly, the *psychology theory* emphasises how the family norms and beliefs around emotion regulation (which then play out in the specific support and messaging that the child receives) can lead to adaptive or mal-adaptive strategies (Section 2.2); and the necessity for experiential learning in terms of delivering any interventions (Section 2.2.3). Finally, the existing *technology* systems discussed in Related Work suggest possible mechanisms to move towards 'authentic learning' approaches (cf., [55]), facilitating parent-child experiences directly around the situations where self-regulation is needed.

We combine these together to propose **two high level design goals** that embody substantial conceptual shifts in how prevention interventions could be designed and delivered: the notion of 'situated interventions' and 'child-led rather than parent driven' approach. In the rest of the section, we then provide an initial validation of the feasibility of these goals within our specific case study context as part of the technology probes deployment findings.

5.1 Design goals

These design goals aim to provide a guidance in how new interventions systems could respond to the current challenges of relying on classroom-based interventions, where emotion regulation is practised on toy examples; and the dependence on trained adults to provide support to children outside of classroom. While these goals are framed around emotion regulation specifically, we expect that they could likely be applied to developing interventions concerning other prevention factors as well. As such, their articulation is predominantly grounded in combining the psychological theory and technology feasibility, with the interview data serving to contextualise the overarching goals in explicit examples and practices we have observed. The next section, 5.2, will then shift the emphasis towards application of the interview data, outlining a particular instantiation of the design goals as a proposed intervention.

5.1.1 Goal 1: 'Situated' interventions. We envision 'situated interventions' as an opportunity to design technologies that allow the families to draw on—and learn from—specific lived experiences as part of the intervention. In other words, the aim would be to flip the existing intervention model that is based on didactic learning (e.g., at an in-person workshop) 'that is to be applied later', towards a model where the intervention empowers and supports both children and parents to learn from the daily emotional challenges they encounter. This would enable the interventions to embed experiential learning as part of everyday situations of stress/anxiety/sadness; using these as the

trigger and opportunity for on-going, iterative learning rather than having to rely on vignettes, role-plays, or the recollection of past experience as is common now.

Psychologically, such 'situated interventions' would correspond to the need for experiential learning that underpins all socio-emotional competencies [29, 70, 79, 130, 153]). As outlined in Section 2.2.3, the limitations of learning 'outside' of the emotional experiences are well known in SEL: the current model of role plays, vignettes and similar techniques during workshops are, in fact, an explicit attempt to generate the necessary emotional material at least to some degree (cf., [8, 133]). For example, the interviews indicate that the reliance on disengagement and distraction offers a possible locale for a situated interventions. The intervention process could tap into such explicit attempts to regulate emotions: the alternative strategies afforded by the intervention could offer more constructive in-the-moment support to deal with the triggering situation (such as scaffolding reappraisal, acceptance, or problem solving). This would allow to tie the intervention support—and the associated learning—to a specific emotional experience that is personally relevant to the parent or child. Finally, the Related Work outlined a number of existing technologies that, albeit used in different settings, are suggesting the feasibility of such situated and experience-based learning: ranging from sensor-based technologies to drive children's science learning [112], capturing fleeting experiences through smart toys [69], to wearables that promote social engagement and playful behaviours in everyday lives [64, 122] to name just a few.

In summary, we argue for exploring an analogous technology-enabled move towards 'authentic learning' [54, 55, 85, 112] as that which has been successfully investigated in the learning sciences (cf. Section 2.1.3). In addition, we hypothesise that such situated intervention models would need to go beyond 'only' embedding existing intervention approaches within a Internet of Things or Ubiquitous Computing systems, but rather require a rethinking of the mechanisms through which learning happens, over which time-scales, and what design components are needed to support the learners in actively engaging and learning from these situations within their social contexts (cf., [131].

5.1.2 Goal 2: Child-led rather than parent-driven. The second key shift we envision technology can enable is foregrounding the child as the immediate target of the interventions. In the current prevention science models, the child is either seen as a 'captive audience' within the in-school programs, or as a secondary actor who is impacted by parental training. The reasons for this are understandable: the existing interventions could not rely on young child to drive the intervention as it is, for example, unlikely that a 6-year old would be able to teach their parents new parenting strategies as a workshop coach might; or directly engage (or want to engage) with a written text on a leaflet sent home.

The on-going, in-the-moment scaffolding facilitated by technology could address both of these issues. It could reposition the child as the main actor of the intervention: both in terms of who is driving the delivery to home as well as the engagement with the intervention once it is there. Beyond the benefits of acting more directly with the child (who is the target population), such a shift towards child-led interventions also brings the ethical interest in empowering the children to learn by themselves, rather than re-iterate/amplify their reliance on adults (especially for those children who might struggle to receive such support).

The interviews suggest that the children are already expected to self-soothe by the parents, but lack direct support to cope and constructively address emotional issues on their own. This leads to the possibly maladaptive strategies indicated by interview data, including distraction, disengagement or 'crying it out'. The existing emotion regulation patterns of going to 'your room' to calm-down, often with toys/electronic devices, and could be particularly amenable to being drawn upon by a situated, child-led intervention. The ability to directly engage and support children

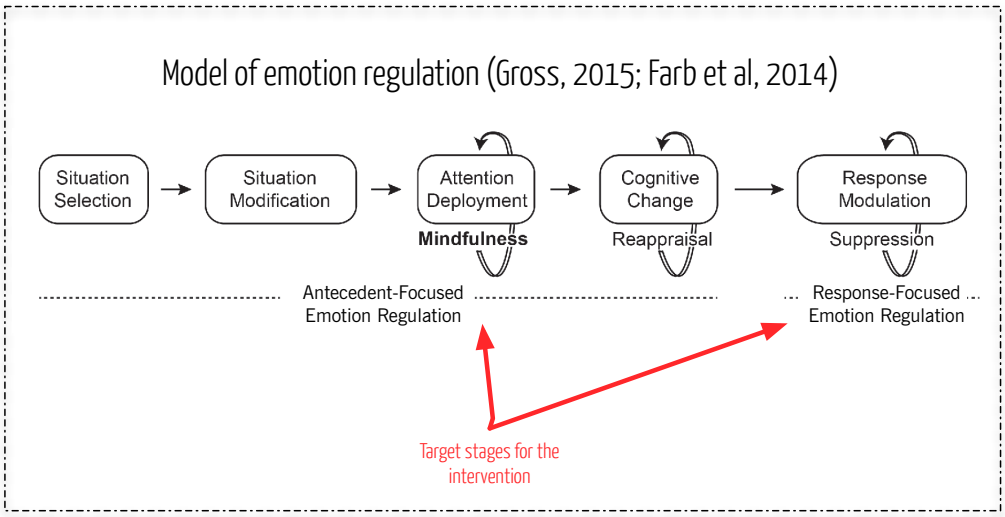

Fig. 1. Emotion regulation theory underpinning the proposed intervention (cf., [51]

would be also coveted by Prevention science: it is well known that if parents are the delivery mechanism/target, training is needed; leading to pragmatic difficulties and high cost [8, 116, 150]. Understanding how an intervention can provide an on-going support and scaffolding that would empower children to learn independently is an important, and so far unsolved, design goal.

5.2 Translating design goals into a possible intervention

The aim of this section is illustrate how the design goals can facilitate articulation of new intervention model. In doing so, we introduce an envisioned intervention design—and a technology probe exploring a some of the key underlying assumptions—as a way to instantiate the proposed design goals into a contextualised system. We briefly describe (i) the design context; and (ii) an outline of envisioned future intervention approach. These are then followed by (iii) a design probe that explores some of the core assumptions in Section 5.3, and finally (iv) findings from a 2-4 days deployments with 14 families in the same under-privileged community the interviews were conducted with (but not with the same families) in Section 5.5. The findings from this design process, technology probe development and the pilot deployments then also lead to articulating three more specific design opportunities, outlined in the Discussion section.

5.2.1 Design approach and context. As part of a broader multi-year project, we combined all the research threads described above as part of envisioning an example intervention. The research team in addition drew on participatory input from parents, children, and SEL experts across a 8 month period: this included a series of co-design workshops (2 with parents, 7 with children) and weekly meetings with SEL experts. This iterative design process will be the focus of a separate paper; here, we will only briefly outline the key aspects of the vision and the initial technology probe prototype, with a specific focus on how the design choices corresponded to the key assumptions.

Our design process drew on the current parental narratives around self-soothing and the resulting reliance of children on having existing objects they use to calm down outlined in Section 4. These practices are not ideal from the mental disorders prevention perspective (cf., section 2.2) and the ultimate intervention goal would be to change these. However, our position is that this will be

social context that an intervention would need to be deployed within; and thus also designed for. Such an approach is grounded on the long history of socio-technical thinking as considering *"the technical features of the system and social features of the work as fundamentally interrelated [97]"*. In fact, we saw the possibility of facilitating a longer-term, internally driven change in practice—that can start from and fit into where parents and children are now—as one of the key benefits of the situated intervention approach; in contrast to the externally delivered workshop interventions that expect a more sudden shift in parents' and children's behaviour.

Intervention logic model. The psychological theories of emotion regulation suggested two types of 'levers' where interventions could attempt to shift child behaviour as part of the family system, i.e., the holistic set of family practices and emotion regulation strategies. First are varied forms of in-the-moment support when emotion regulation is needed, such as introducing/facilitating the use of constructive strategies when children feel anxious, sad, or angry – cf., Section 2.2) and Fig 1 for the theoretical model underpinning this thinking. Second are attempts at changing the broader emotion regulation strategies that are available to children in their daily lives, for example through reshaping the social environment (such as parent-child interactions) and explicit competence building for children and/or parents. While the latter is key to a longer term change, we also saw that as much harder to deliver, without the system establishing a strong 'foothold' within the family everyday practice first.

As a result, the proposed intervention model reflects these two components as building on each other in two phases (see Figure 2 for a diagram): the first phase is grounded in directly supporting children within the moments they would normally attempt to calm down (e.g., by going to their room). We envisioned that, in such a case, the children would not only receive immediate benefits when they are expected to self-regulate (thus motivating continued use), but also start building a sense of mastery and physically situated calming rituals through such repeated engagements. The second phase then builds on this child-oriented support, using the specific experiences with the intervention to start engaging the parents into the intervention, with the aim of offering alternative approaches and narratives for emotion regulation on the family level. We envision that a possible mechanism could rely on the notion of 'intervention portals' (cf., [132]), whereby a technology-enabled experience can facilitate parent-child discussion and continued learning from everyday interactions.

Intervention narrative. Developing such vision into a full-fledged intervention will require substantial interdisciplinary effort over the next year. However, the technology probe described below started to validate the initial steps towards first intervention phase – exploring possible design responses to support the in-the-moment emotion regulation in ways that are well-embedded within existing children's practices as identified from the interviews.

On a conceptual level, we were inspired by the existing body of work on the soothing effects of animal therapy [14, 100, 105, 136], including the design narratives of responsibility, care, and nurture. The proposed design has thus centred around the notion of a '**worried pet**' – a 'lost' creature, who is often anxious and can be soothed by calm, stroking movements. This particular choice of narrative was aimed at creating a *sense of relationship* between the child and the toy, drawing on the interactivity and interdependence of the 'creature': we hypothesised that framing the creature in need of assistance would draw on the psychological effects of calming down by soothing 'someone else' (cf., [11, 15]); and the in-the-moment soothing effects of doing so might result in a shift in the children's mindset around emotion regulation over time (cf., [40, 120] for the importance of emotion mindsets). From a more user-centred view, the selection of a plush animal (as described below) seemed to fit—and graft onto—the existing patterns of object-facilitated self-regulation that children described.

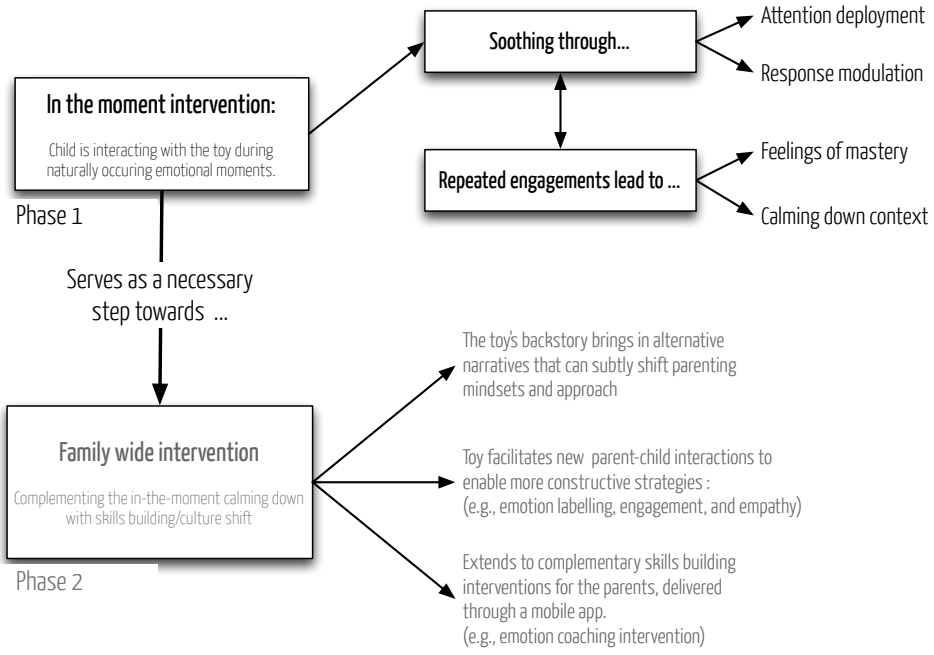

Fig. 2. Logic model of the proposed intervention

We now move to introducing the resulting technology probe as a way to instantiate some of the proposed design directions in a specific design prototype.

5.3 Technology probe form and design

The aim of this section is to serve as an initial validation of the feasibility of Phase 1 of the proposed intervention model—and by extension, the design goals that guided its development. As such, it should be read more as an exploration of the articulated design space; rather than an attempt to evaluate a fully fledged intervention, or show its psychological effectiveness of the technology probe. In what follows, we briefly outline the probe design, and findings from a pilot 2-4 days deployments with 14 families in the same under-privileged community the interviews were conducted with (but not with the same families). The findings from these deployments and the design process then also lead to articulating three more specific design opportunities on how the currently limited system could be extended into the full intervention, outlined in the Discussion section.

Overview. The external prototype takes the form of a hand-crafted plush toy (see Fig 3-a), which was designed to travel home with the child from school and support in-the-moment calming down strategies. The interaction relied on a number of sensors embedded in the 'creature' that registered haptic interactions with the toy – see Figure 3-b. In addition, a small vibration motor was used to indicate the creature's state by mimicking a frantic 'heartbeat'. If the creature was calming down in response to the child's touching of the sensors, the heartbeat slowed down and eventually turned into happy purring. These haptic interaction patterns were designed drawing upon research with children in our initial target age group (8-10) concerning their preferred fidget materials and fidgeting patterns, as well as research concerning fidget materials and their link to self-regulation in adults [72]. This evidence suggested particular kinesthetic and tactile affordances that would

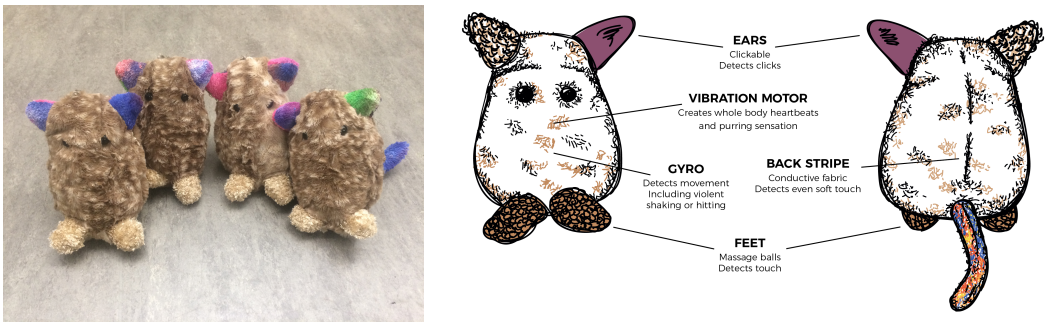

Fig. 3. (a) The technology probe design; (b) Overview of the interactive components in the technology probe

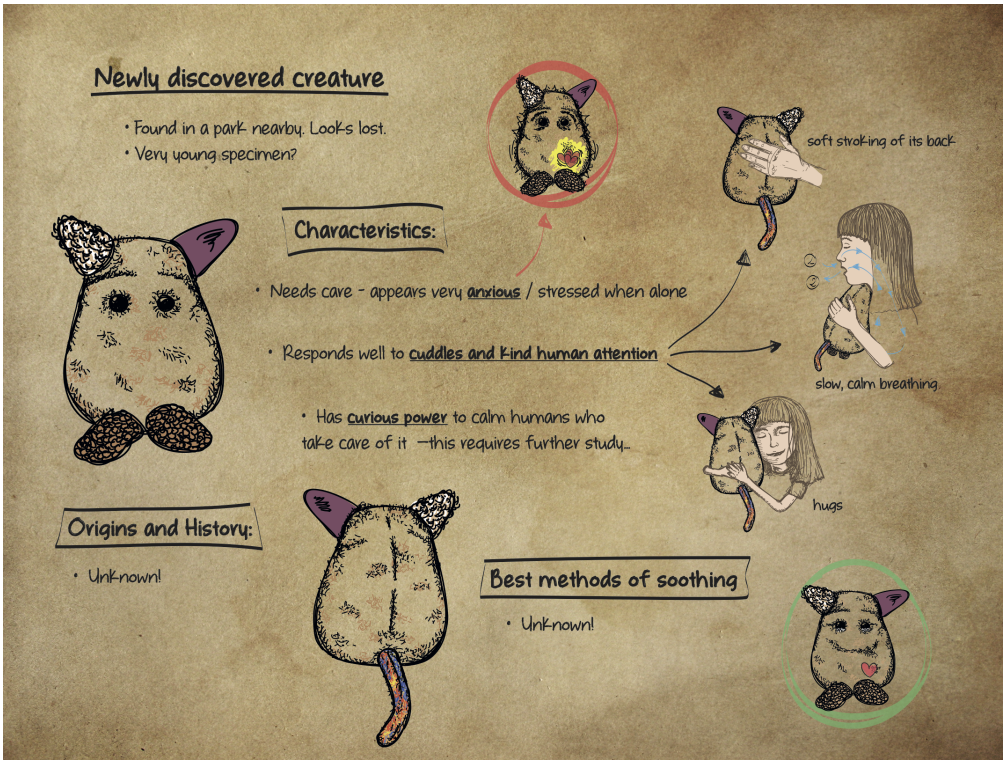

Fig. 4. Example design of the information children received

facilitate soothing effects. We hypothesised that interacting with a toy that made use of these affordances would aid in the child's self-regulation. We envisioned that, in further iterations, the sensed patterns of use could be utilised as a form of personal informatics data, both to support the child in understanding/developing calming strategies as well as surfacing these to the parents to facilitate parent-child discussion.

To accompany the tactile in-the-moment interactions, we included a *discovery book* to facilitate parent-child interactions. We took inspiration in cultural probe methods [16, 42, 74] to design

photo activities for children to do with their parents[1]. The goals of the discovery book were two-fold. Firstly, it provided us with the opportunity to collect rich qualitative data in line with prior use of cultural probes activities. Secondly, and perhaps more importantly, we aimed to use these interactions as a first foray into the family-wide intervention design space: we wanted to explore if such interactions, together with the soothing-by-caring narrative brought in by the toy, might start introducing more constructive context into the family practices as well as open up topics that would not have been discussed otherwise, even with the very limited deployment timeframes.

5.4 Deployment methodology

The pilot deployment had two aims: First, we sought to understand how the toy might be appropriated at home over a short period of time, including how children appropriated the toy and the core narrative of the lost pet story (hypothesised drivers for child-led, long-term engagement); as well as whether they would interact with it in moments of stress and whether it had soothing effects (hypothesised drivers for the in-the-moment emotion regulation intervention). Second, we hoped to gain initial understanding of the potential social dynamics that would guide the design of the family-wide components (i.e., potential for extension into Phase 2 of the logic model). Given the short time span of the deployment, we did not expect to see any of the effects hypothesised to arise from on-going use, nor substantial changes in family practice. We were, however, interested in collecting qualitative indicators of how likely such changes might be over longer-term deployments to guide and inform future work.

Participants. The technology probes were deployed in three waves to families of 14 children (6 girls, 8 boys, aged 6-8). These were recruited by a school in the under-privileged community in a UK city: first wave deployed with 5 children selected by the school counsellors to represent a varied range of family situations and special needs. After seeing the creatures, an additional class requested to participate, leading to 9 more families so far (in two waves, due to limited number of prototypes available).

Research process. Children who gave explicit assent (and whose parents gave consent) were given the creature, discovery book, and a simple digital camera by the teacher or school counsellor, to keep at home for 2-4 days (depending on the day of deployment and school pragmatics). A day or two after the toys were returned, we interviewed each child individually, in the presence of the school counsellor. During the interviews the children had a chance to interact with their creature again, as a way to help them recall and describe their experience of having it at home. We also used the photos they took as prompts to ask them about their interaction with the toy. Our aim was to complement the interview data with a richer understanding about how children experienced having the toy at home. We attempted to recruit parents to be interviewed as well (mediated by the school counsellor), but with little success, despite being able to offer monetary incentives – leading to a single informal interview. This low response rate was seen as expected by the school counsellor and explained by language barriers (English as a second language) as well as general distrust of speaking to 'authorities'. Such observations further underscore the issues that prevention programs face in terms of gaining trust and access to parents, as already described in the literature (e.g., [109, 132]).

Analysis. The analysis process was the same as that outlined in section 3.1 for phase 1 interviews, with the addition of data from the discovery books. We do not include a full analysis of photo

[1]Nine activities altogether, probing into family emotion practices. For example, we asked the child to *"Take a series of 3 to 5 photos explaining what your parents do when they want to calm down."*, to *"Take a photo of something of someone that helps you relax.", or to* "Take a photo of something you do with your adults that makes you really happy."

data here; within the context of this study, photos were utilised as an ice breaker activity to create a comfortable space for discussion, and to stimulate conversation by invoking comments and memories from children about their interactions with the toy. The results of a more comprehensive analysis of photo data will be reported in a separate paper.

5.5 Findings

In line with the proposed broader intervention, we discuss the key themes that emerged from our analysis, with respect to the logic model and the underlying design goals: facilitating *child-led mechanisms* through the child-toy relationship; and the *situated intervention* through in-the-moment soothing effects of interacting with the toy. To protect anonymity, participants are referred to by using C for 'child', followed by a participant number. The researcher conducting the interviews is labelled as 'R' throughout. Paraphrasing is indicated by words surrounded by brackets, and non-verbal actions, such as nodding their head in agreement, appear between double parenthesis, e.g., ((nods head 'yes')) .

5.5.1 Emotional connection/attachment to the toy. Our findings indicate that even in the limited amount of time children had the toy at their homes, all children appeared to form an emotional connection to it which in turn drove consistent engagement with the probe. The physical design and associated narrative of the toy being anxious and needing to be soothed appeared to have facilitated such emotional attachment: the toy was not perceived as a device and most children did not refer to it as a toy during the interviews, but rather as a *'creature'* they had to care for, including calling it *'he'* or *'she'*. Children often attributed human-like qualities to the toy, such as feelings (*'happy'*, *'anxious'*, *'sad'* or *'scared'*) and intentionality, as well as personality characteristics, e.g. being *'shy'*. For example, C2 mentioned how

> "C2: I think he was scared when he first met me. R: So what did you do for the toy not to be scared of you? How did you become friends with it? C2: I hugged him, I stroked him, I let him sleep and rocked him." [C2]

Moreover, imbuing the toy with human-like traits and various mental states may have played a part in children's continued engagement with it: attributing sentience to the toy seemed to make children empathise with and take care of it. The quotes below illustrate the types of emotional interactions children were telling us about during the interviews:

> "I also discovered this new thing. Whenever you leave him alone and you're very far away from him, he actually gets really anxious. [...] But I would actually never, ever, ever, ever, ever leave him in his nest alone." [C3]

> "The day I had to bring him back, he came to school with me and met all my friends. [...] And then [another boy] was like 'Can I punch him?' and I was like 'No, I can't let you do that!'. So yeah, I told them to rock him or let him sleep or just hold him. Yeah, so they all did that." [C2]

> "It was sad when it was sleeping because it couldn't go to sleep. R: Oh, she couldn't go to sleep? And how did you help her? C: I just closed her eyes ((covers the creature's eyes with his hand))." [C14]

At the end of the deployment study, many of the children said they were *"really sad when I had to leave it"* and that they had gotten *"attached to it"*. In one particular case, a child was so upset to have to give it away that we let her keep the toy for one more day. The following quotes are illustrative of children's reactions to having to give the toy back:

> "[I was really sad when] when it had to come back. R: Why? C: Cos he was my best friend!" [C9]

> "I was really sad when I had to leave it, because I had such a good time with it and I will never be the same without it." [C5]

These results suggest that the design choice of coupling the toy's interactivity with the 'dependency' narrative was conducive creating a sense of relationship between children and the toy. Moreover, the responses children gave then indicate that they readily assumed the role of the caretaker, with a responsibility to nurture and care for the creature. Interestingly, even the very simple haptic feedback—driven internally by a linear, 6-state automaton—was enough to generate rich models of the creature's 'mental states', which seemed to facilitate a sustained engagement with it. While this data is likely affected by novelty and short term deployment, we observed strengthening (rather than weakening) of the relationship for longer stays. This would suggest that longer-term engagements could be feasible.

5.5.2 Self-regulation value of toy. Children's interview responses as well as the photo data indicate that the toy was perceived to have a calming effect on them; for some it also provided direct in-the-moment support during emotional moments. All the children mentioned that calming the toy down was an enjoyable, *'happy'* experience for them. For example, C14 described that *"[When I tried calming it down] I felt great. R: You felt great? Why? C: Because I like calming people down."* The children often talked about the *'calming'* interaction during everyday moments. The following quote illustrates such more mundane moments:

> "R: I see you've taken a photo of something or someone that helps you relax. Can you tell me which one it is? C: When he's going to bed. R: So when he's going to bed it makes you relax? ((child nods 'yes') R: How does that make you relax? C: When he's calming down." [C10]

Moreover, in all instances where children mentioned that they encountered an emotion-eliciting situation while they had the toy at home, they also described how engaging with the toy helped them calm down. The following quotes illustrate the kinds of stories we heard:

> "He made me calm down by just lying on top of me. He just makes me calm down, I don't know how. He just does." [C3]

> "[...] Normally when I have a row with [my sister] I just go back to bed and watch TV, but [the toy] - cos you've got to hug her and stroke her, take breaths in and out - it helped a lot." [C4]

> "C8: I [was] sad because [...] someone pushed me over. R: And what did you afterwards to calm down? C8: I stroked it and hugged him. R: And did that make you calm down? C8:Yeah." [C8]

Such experiences would suggest support for two important aspects of the proposed logical model: the in-the-moment soothing effects that arose naturally through interactions with the creature; and the choice of utilising the interactions as a deliberate calming strategy at least for some of the children. The children's accounts indicated initial support for both of the mechanisms we hypothesised could drive the in-the-moment calming effects. These included the attention shift of focus from the emotion-eliciting situation towards the creature as part of the soothing-by-caring narrative; as well as the effects of the haptic interactions patterns designed to soothe the toy (suggested by the value children associated with close bodily contact with the toy). Such explicit awareness of the calming effects is promising and could motivate continued use during longer-term deployments.

5.5.3 Appropriation of the toy in families. Children told us that they engaged with toy frequently throughout the day and included it in their everyday routines and activities – many children mentioned they *"kept taking him wherever [they] went" [C11]*. The toy was readily adopted as a social partner, with children reporting they played games together, watched movies, engaged in pretend play, or slept in the same bed. In all these instances, the children were framing the experience as that of a partnership: the toy was actively involved in the activity; or transforming the experience by being close. For example, C5 mentioned how *"I let him have a go at my [game] – I got his feet and I touched the buttons with them."* While the majority of children were fully positive

about the on-going caring experience, we observed a single case where the perceived responsibility for the toy's well-being began to interfere with other activities:

> "I was in the middle of watching Jumanji and it got angry and I had to calm it down. [...] R: And after you calmed it down do you remember how you felt? C6: Happy. So I can start watching Jumanji again." [C6]

Data from children interviews and photos taken by children as part of the activities they had to complete suggest that the toy was also engaged with by parents, siblings, other members of the family (e.g., cousins), and in some cases by children's friends. Children described how they were *"each having turns to make it calmer [C2]"* with their siblings, or were more protective and had to negotiate who gets to play with it and when:

> "I didn't let [my mum] play with him the first night. Well, she did a little bit, but then I was like 'Mum, it's my first night with him'." [C5]

An important part of the notion of child-led, situated intervention was the ability of the probe to become embedded and incorporated as part of the everyday practice. Based on the children's accounts, the creature fit well within their daily routines and was frequently and naturally engaged with over the course of the deployment; while understood and interacted with as a 'partner'. While more research is needed (e.g., contrasting interactive vs non-interactive deployment), the current data could be seen as further supporting the importance of projecting 'sentience' and human-like emotions onto the creature, which in turn lead to the perceived relationship and value of 'shared experiences'.

5.5.4 Facilitating parent-child interactions. The findings are less uniform in terms of how successful the toy and probe materials were in facilitating additional parent-child interactions. In approximately two thirds of families, the parents seemed to be often playing with the toy themselves, and helping their children take photos and complete the activities in the accompanying booklet.

> "My mum helped me find some of the things [that calm it down] like rocking it." [C2]
>
> "[In this photo my mum] was cuddling it and then she was reading it a book." [C10]
>
> "The [...] creature loved my mum when I gave it to her and that's why it always asked her to calm it down." [C6]

In other families, the parents seemed less engaged with the toy, indicated both by interview data and by fewer booklet activities completed. Finally, we had a single case of a parent who, according to the child interview, explicitly disliked the creature: *"R: What did your mummy think of the creature? C11: She was annoyed. R: She was annoyed? Why was she annoyed? C: Because I kept taking him wherever I went." [C11]* The lack of more substantive data around this particular case (as well as the other aspects of parental involvement) is likely due to our inability to recruit parents in this community for post-hoc interviews. It also indicates the need for further work on the parenting side of the intervention, including identifying additional mechanisms of facilitating parent/child interactions beyond photo-based activities; as discussed in more depth below.

6 DISCUSSION

We started this paper by highlighting the very limited body of literature that would examine technology-enabled interventions within the context of mental disorders prevention; with a focus on emotion regulation for families of children aged 6-10 as a particular case study setting to start examining this interdisciplinary area. The *key conceptual contribution of this work* lies in Section 5.1, which combines interview data, psychology theory and technology feasibility into an articulation of two design goals underpinning the rest of this work: *the notion of 'situated interventions' and*

'child-led rather than parent driven' approach. To best of our knowledge, these propose a novel approach to technology-enabled prevention interventions that could imply fundamental changes in how such interventions are designed and delivered (cf., [130]), while emphasising the inherently socio-technical nature of such endeavours. The 'second half' of the paper then offers an initial validation of the feasibility of designing such interventions: we presented a proposed intervention model, followed by a technology probe deployment testing some of the basic assumptions, i.e., the in-the-moment emotion-regulation support, and the child-led engagement through a relationship with the toy.

In what follows, we first discuss how the empirical data from the technology probe deployment feeds back to the design goals identified in Section 5.1, including the limitations of the current probe. We then specifically focus on the possible design mechanisms that might enable extending this—and other interventions—to serve as sites for situated, family-wide interventions.

6.1 Linking design goals, proposed intervention model, and technology probe results

Though the technology probe is far from a fully effective intervention, the field data provide a preliminary validation for the feasibility of the proposed intervention model and, by extension, also the design goals: the interview data suggest that children drove the interaction with the toy at home by incorporating it into their daily routines and frequently engaging with it throughout the day (situated & child-led). Moreover, the probe appeared to be conducive to facilitating a relationship and emotional connection from the children, which gave meaning to the soothing interactions (child-led). What was particularly interesting was the large proportion of children reporting that the physical, in-the-moment interactions were effective in helping them calm down and relax (situated). Despite the short time and only initial intervention design, the data suggest that the toy was interacted with naturally when some of our participants perceived the need to calm down (situated, child-led); and was seen as a positive change (cf., quotes from Section 5.5.2).

There are however also clear limitations in the probe design as well as the length of deployment, with the findings highlighting many of the current gaps that would need to be resolved as part of extending the current technology probe prototype into the envisioned prevention intervention: In spite of the positive preliminary data, it is not clear if the existing prototype would lead to developing new emotion regulation skills for children that would persist after the toy is being taken away; or 'just' serve as crutch that has positive effects while it is around (similarly to, e.g., effects of the Paro robotic seal [11, 15, 21, 89, 151]). Specifically, more research is needed to understand how similar in-the-moment interactions can be extended to include more explicit intervention, including particular skills and competencies; as well as how much of the patterns we observed are due to novelty effects. Similarly, the design choices we made were made in the context of a particular age group and community; while we would imagine the underlying mechanisms might work similarly for other communities, the specific form factor, aesthetic, and narrative is clearly limited to the age group and culture of our participants.

Moreover, the findings are much less clear about the success or failure of the probe in starting to facilitate the broader family-wide intervention, including the facilitation of new emotion-regulation narratives and practices to the families. While this is partially understandable due to the short-term deployment, we assume that there are more fundamental issues at play. We expect that much more co-design and participatory work will be needed to better understand the mechanisms through which similar interventions could reach—and more importantly provide value to—parents. The interview data highlighting the importance placed on emotion regulation as well as the perceived lack of existing resources would suggest that parents might be open to such interventions, if these are designed sensitively and fit into their life-worlds.

6.2 Socio-technical dimensions of the proposed intervention model

The envisioned model of situated interventions is inherently dependent on fitting in with—while sensitively facilitating a change of—social practices in the home. As such, there are multiple aspects of 'socio-technicality' that will come into play [9, 97, 134]; and the initial technology probe described here has predominantly focused on socio-technical as the fit with the child's life and experience.

However, the ultimate test of the effectiveness of such situated interventions capabilities to extend beyond such purely child-oriented, in-the-moment support and into the wider family contexts. As outlined above, the pilot work here has only few answers to offer here, given the limited time-span of the deployment as well as difficulties with gathering parental feedback. In what follows, we propose a series of three 'design opportunities' that outline some of the design mechanisms that we envision could guide the development of interventions in this space. While far from exhaustive, we hope these design directions could serve as inspiration for others, and provide a next step towards instantiating the socio-technical design thinking needed to instantiate the two design goals that form the crux of the paper here. The design opportunities outlined below emerge from our attempt to articulate, reflect on, and abstract the conceptual choices that underpinned the intervention logic model design in Section 5.2.

6.2.1 Opportunity 1: Physical objects as 'intervention portals'. The first opportunity concerns the use of interactive physical objects as stable 'sites' of the intervention that also serve as 'portals' to other interactive content. For example, the technology probe 'intervention' was centred around a physical toy, affording a set of situated actions children could do to self-soothe. These in-the-moment interactions however also served as a starting step towards a range of associated narratives and parent-child interactions beyond the immediate toy use. Prior work has already shown how physical objects are well suited for in-the-moment support (e.g., [111]), can become associated with rich behavioural/emotional connotations over time (e.g., [132]); and thus serve as (sub)conscious reminders just by being around (e.g., [103]). Finally, we envision that, in contrast to more transient lesson-based interventions, on-going interaction with a physical object can have different properties, with the intervention content slowly developing through continued use; such as illustrating skills development over time ('leveling up'). For example, a number of projects have explored the power of combining digital and physical to drive complex games [61, 62, 122], social interactions (e.g. [63], and is also at the heart of many situated learning approaches in formal education (e.g., [7, 112]).

6.2.2 Opportunity 2: Family intervention as a narrative change. Long term situated interventions might not necessarily require explicit skills building, but rather aim to change ways in which families think about or approach emotional aspects. For example, the interviews indicate that the notion of emotions as transient and uncontrollable is common. Targeting and changing such narratives could, by itself lead to positive effects [40, 75, 110, 120, 148]. Similarly, the intervention could target facilitating the identification of emotions and discussing it with one another. Psychologically, such process of 'labelling' emotions is at the heart of many existing curricula: it been shown to directly support emotion regulation by strengthening executive control [50, 117]. In addition, involving parents in such discussions is crucial for the shift from emotion dismissing to more emotion-aware parenting approaches, associated with more adaptive ER strategies [36, 45, 114]. Interactive technologies have been demonstrated to bring parents and children [59] as well as siblings [46] into productive relationship with one another particularly within the 'magic circle' of play [123]. Interactive technologies such as games are additionally becoming a part of everyday family life, helping to foster relationships and positive emotional connections [107]. Across all these examples, the intervention itself might lie not in teaching parents or children specific calming down

strategies (such as tactic breathing or remembering to count), but rather in how it re-conceptualises the way in which emotion is perceived and socially constructed within the family.

6.2.3 Opportunity 3: Facilitating new interactions. Finally, we envision the new situated interventions as catalysts for deeper emotional connection within the family, rather than further siloing the individualist interactions that the interview data suggest is happening. This is important not only due to concerns around the changes to family structure technologies can bring (cf., Sherry Turkle's work [141–143]), but also due to the psychological literature that shows the strong impact of family strategies on children's emotion regulation and the emotion-attentive parenting approaches that are conducive to adaptive strategies . As such, an intervention—technological or otherwise—that would aim to further individualise and separate would likely be unsuccessful. Technologically, we suggest that situated interventions could co-opt approaches similar to the on-going work in psychotherapy, where the introduced technology facilitates interactions that were seen as problematic before or for which there were no words. For example, the work on gNats island [24, 25, 30] provides one example where a game provides am effective space for teen and a therapist to interact around, together. Digital games and play offer many examples of intervention to support rich interpersonal interaction and the deepening of social connections [28, 61, 125]. Ultimately, the goal of successful interventions is to 'teach and disappear' [130] – we argue that facilitating the emergence of new parent-child interactions and family narratives could be one opportunity for such a stable change.

7 CONCLUSIONS AND FUTURE WORK

Preventative interventions that develop protective factors against mental health disorders can have substantial impact on life outcomes of children. Focusing on emotion regulation as a case study example, this paper brings together an understanding of existing family practices with psychological theories and review of technology feasibility. As a result, we propose that technology-enabled interventions could lead to a new model of situated, child-led interaction, that could fundamentally alter how preventative interventions are designed and delivered; as well as the type of resources needed for their effective functioning. These research agenda setting goals were then instantiated within a proposed intervention model and an associated technology probe, with promising results from real-world deployment with 14 families. These provide a preliminary validation for the feasibility of the proposed framework.

However, the technology probe deployed in the research described in this paper was only a first foray into the design space that has been articulated. Next steps in this research program would include further refinement of this particular technological intervention and development of more extensive accompanying scaffolding for building children's skills and for encouraging dialog between parents and children, toward a more extensive pilot test. We plan to work closely with educators and psychologists to situate this and other interventions to appropriately supplement the current state-of-the-art in social emotional learning tools and techniques.

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REFERENCES

[1] 2011. Theoretical Background and Conceptual Framework : Summary of Research Supporting The Kimochis Educator ' s Tool Kit. (2011), 1–14.

[2] Amelia Aldao. 2013. The Future of Emotion Regulation Research : Capturing Context. *Perspectives on Psychological Science* 8, 2 (2013). DOI: http://dx.doi.org/10.1177/1745691612459518

[3] Amelia Aldao, Susan Nolen-Hoeksema, and Susanne Schweizer. 2010. Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review* 30, 2 (2010), 217–237. DOI: http://dx.doi.org/10.1016/j.cpr.2009.11.004

[4] Krestina L. Amon and Andrew Campbell. 2008. Can children with AD/HD learn relaxation and breathing techniques through biofeedback video games? *Australian Journal of Educational and Developmental Psychology* 8 (2008), 72–84.

[5] Alissa N. Antle, Leslie Chesick, and Elgin-Skye Mclaren. 2018a. Opening up the Design Space of Neurofeedback Brain–Computer Interfaces for Children. *ACM Transactions on Computer-Human Interaction* 24, 6 (2018), 1–33. DOI: http://dx.doi.org/10.1145/3131607

[6] Alissa N Antle, Leslie Chesick, Srilekha Kirshnamachari Sridharan, and Emily Cramer. 2018b. East meets west : a mobile brain-computer system that helps children living in poverty learn to self-regulate. *Personal and Ubiquitous Computing* (2018), 1–29.

[7] Alissa N. Antle and Alyssa F. Wise. 2013. Getting down to details: Using theories of cognition and learning to inform tangible user interface design. *Interacting with Computers* 25, 1 (2013), 1–20. DOI: http://dx.doi.org/10.1093/iwc/iws007

[8] R Bar-On, K Maree, and MJ Elias. 2007. *Educating people to be emotionally intelligent.* Greenwood Publishing Group.

[9] Gordon Baxter and Ian Sommerville. 2011. Socio-technical systems: From design methods to systems engineering. *Interacting with Computers* 23, 1 (jan 2011), 4–17. DOI: http://dx.doi.org/10.1016/j.intcom.2010.07.003

[10] Clive R Belfield, Milagros Nores, Steve Barnett, and Lawrence Schweinhart. 2006. The High/Scope Perry Preschool Program: Cost Benefit Analysis Using Data from the Age-40 Followup. *J. Human Resources* XLI, 1 (jan 2006), 162–190. DOI: http://dx.doi.org/10.3368/jhr.XLI.1.162

[11] Roger Bemelmans, Gert Jan Gelderblom, Pieter Jonker, and Luc de Witte. 2012. Socially assistive robots in elderly care: A systematic review into effects and effectiveness. *Journal of the American Medical Directors Association* 13, 2 (2012), 114–120. DOI: http://dx.doi.org/10.1016/j.jamda.2010.10.002

[12] Howard Berenbaum, Chitra Raghavan, Huynh-Nhu Le, Laura L Vernon, and Jose J Gomez. 2003. A taxonomy of emotional disturbances. *Clinical Psychology: Science and Practice* 10, 2 (2003), 206–226.

[13] Lisa J Berlin and Jude Cassidy. 2003. Mothers' Self-Reported Control of Their Preschool Children's Emotional Expressiveness: A Longitudinal Study of Associations with Infant–Mother Attachment and Children's Emotion Regulation. *Social Development* 12, 4 (2003), 477–495.

[14] Virginia Bernabei, D De Ronchi, T La Ferla, F Moretti, L Tonelli, B Ferrari, M Forlani, and A R Atti. 2013. Animal-assisted interventions for elderly patients affected by dementia or psychiatric disorders: a review. *Journal of psychiatric research* 47, 6 (2013), 762–773.

[15] Jaishankar Bharatharaj, Loulin Huang, and Ahmed Al-Jumaily. 2015. Bio-inspired therapeutic pet robots: Review and future direction. *ICICS 2015* (2015), 0–4. DOI: http://dx.doi.org/10.1109/ICICS.2015.7459940

[16] Kirsten Boehner, Janet Vertesi, Phoebe Sengers, and Paul Dourish. 2007. How HCI interprets the probes. In *CHI '07*. 1077–1086. DOI: http://dx.doi.org/10.1145/1240624.1240789

[17] M.A. Brackett and P. Salovey. 2004. Measuring emotional intelligence as a mental ability with the Mayer–Salovey–Caruso Emotional Intelligence Test. In *Measurement of emotional intelligence (pp.*, G Geher (Ed.). Nova Science Publishers, Hauppauge, NY, 179–194.

[18] Caroline Braet, Lotte Theuwis, Kim Van Durme, Julie Vandewalle, Eva Vandevivere, Laura Wante, Ellen Moens, Sandra Verbeken, and Lien Goossens. 2014. Emotion Regulation in Children with Emotional Problems. *Cognitive Therapy and Research* 38, 5 (2014), 493–504. DOI: http://dx.doi.org/10.1007/s10608-014-9616-x

[19] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative research in psychology* 3, 2 (2006), 77—-101. http://www.tandfonline.com/doi/abs/10.1191/1478088706qp063oa

[20] John C Buckner, Enrico Mezzacappa, and William R Beardslee. 2003. Characteristics of resilient youths living in poverty: The role of self-regulatory processes. *Development and Psychopathology* 15, 1 (2003), 139–162. DOI: http://dx.doi.org/10.1017/S0954579403000087

[21] Adrian Burton. 2013. Dolphins, dogs, and robot seals for the treatment of neurological disease. *The Lancet Neurology* 12, 9 (2013), 851–852. DOI: http://dx.doi.org/10.1016/S1474-4422(13)70206-0

[22] Meng-Ying Chan, Yi-Hsuan Lin, Long-Fei Lin, Ting-Wei Lin, Wei-Che Hsu, Chia-yu Chang, Rui Liu, Ko-Yu Chang, Min-hua Lin, and Jane Yung-jen Hsu. 2017. WAKEY: Assisting Parent-child Communication for Better Morning Routines. *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (2017), 2287–2299. DOI: http://dx.doi.org/10.1145/2998181.2998233

[23] Drew Cingel and Drew. 2017. How Parents Engage Children in Tablet-Based Reading Experiences. *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing - CSCW '17* (2017), 505–510. DOI: http://dx.doi.org/10.1145/2998181.2998240

[24] David Coyle, Gavin Doherty, Mark Matthews, and John Sharry. 2007. Computers in talk-based mental health interventions. *Interacting with Computers* 19, 4 (jul 2007), 545–562. DOI: http://dx.doi.org/10.1016/j.intcom.2007.02.001

[25] David Coyle, Nicola McGlade, Gavin Doherty, and Gary O'Reilly. 2011. Exploratory evaluations of a computer game supporting cognitive behavioural therapy for adolescents. In *CHI '11*. ACM Press, New York, New York, USA, 2937–2946. DOI: http://dx.doi.org/10.1145/1978942.1979378

[26] Ashley B. Craig, Emily R. Brown, James Upright, and Melissa E. DeRosier. 2016. Enhancing Children's Social Emotional Functioning Through Virtual Game-Based Delivery of Social Skills Training. *Journal of Child and Family Studies* 25, 3 (2016), 959–968. DOI: http://dx.doi.org/10.1007/s10826-015-0274-8

[27] Susanne A Denham, Susan Renwick-DeBardi, and Susan Hewes. 1994. Emotional communication between mothers and preschoolers: Relations with emotional competence. *Merrill-Palmer Quarterly (1982-)* (1994), 488–508.

[28] Ansgar E Depping and Regan L Mandryk. 2017. Cooperation and Interdependence: How Multiplayer Games Increase Social Closeness. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*. ACM, 449–461.

[29] Adele Diamond, W S Barnett, Jessica Thomas, and Sarah Munro. 2007. Preschool program improves cognitive control. *Science* 318, 5855 (2007), 1387–1388. DOI: http://dx.doi.org/10.1126/science.1151148

[30] Gavin Doherty, David Coyle, and John Sharry. 2012. Engagement with Online Mental Health Interventions: An Exploratory Clinical Study of a Treatment for Depression. In *CHI '12*. ACM Press, New York, New York, USA, 1421. DOI: http://dx.doi.org/10.1145/2207676.2208602

[31] Judy Dunn, Jane Brown, and Lynn Beardsall. 1991a. Family talk about feeling states and children's later understanding of others' emotions. *Developmental Psychology* 27, 3 (1991), 448.

[32] Judy Dunn, Jane Brown, Cheryl Slomkowski, Caroline Tesla, and Lise Youngblade. 1991b. Young children's understanding of other people's feelings and beliefs: Individual differences and their antecedents. *Child development* 62, 6 (1991), 1352–1366.

[33] Joseph A Durlak, Roger P Weissberg, Allison B Dymnicki, Rebecca D Taylor, and Kriston B Schellinger. 2011. The impact of enhancing students' social and emotional learning: a meta-analysis of school-based universal interventions. *Child development* 82, 1 (2011), 405–32. DOI: http://dx.doi.org/10.1111/j.1467-8624.2010.01564.x

[34] Melcer EF and Katherine Isbister. Bots & (Main) Frames: Exploring the Impact of Tangible Blocks and Collaborative Play in an Educational Programming Game.. In *CHI '18*. ACM Press, upcoming.

[35] Nancy Eisenberg, Amanda Cumberland, and Tracy L. Spinrad. 1998. Parental Socialization of Emotion. *Psychological Inquiry* 9, 4 (1998), 241–273. DOI: http://dx.doi.org/10.1207/s15327965pli0904_1

[36] Nancy Eisenberg, Richard a Fabes, and Bridget C Murphy. 1996. Parents' Reactions to Children' s Negative Emotions : Relations to Children' s Social Competence and Comforting Behavior. *Child Development* 67, 5 (1996), 2227–2247. DOI: http://dx.doi.org/10.1111/j.1467-8624.1996.tb01854.x

[37] Nancy Eisenberg, Sandra Losoya, Richard A Fabes, Ivanna K Guthrie, Mark Reiser, Bridget Murphy, Stephanie A Shepard, Rick Poulin, and Sarah J Padgett. 2001. Parental socialization of children's dysregulated expression of emotion and externalizing problems. *Journal of family Psychology* 15, 2 (2001), 183.

[38] Maurice J Elias. 1997. *Promoting social and emotional learning: Guidelines for educators*. ASCD.

[39] Sean Follmer, Hayes Raffle, Janet Go, Rafael Ballagas, and Hiroshi Ishii. 2010. Video play: playful interactions in video conferencing for long-distance families with young children. In *Proceedings of the 9th International Conference on Interaction Design and Children*. ACM, 49–58.

[40] Brett Q. Ford, Sandy J. Lwi, Amy L. Gentzler, Benjamin Hankin, and Iris B. Mauss. 2017. The cost of believing emotions are uncontrollable: Youths' beliefs about emotion predict emotion regulation and depressive symptoms. *Journal of Experimental Psychology: General* (2017). DOI: http://dx.doi.org/10.1037/xge0000396

[41] H. C. Fox, S. R. Axelrod, P. Paliwal, J. Sleeper, and R. Sinha. 2007. Difficulties in emotion regulation and impulse control during cocaine abstinence. *Drug and Alcohol Dependence* 89 (2007), 298–301.

[42] William W. Gaver, Andrew Boucher, Sarah Pennington, and Brendan Walker. 2004. Cultural probes and the value of uncertainty. *interactions* 11, 5 (sep 2004), 53. DOI: http://dx.doi.org/10.1145/1015530.1015555

[43] Noni K Gaylord-Harden. 2008. The influence of student perceptions of parenting and coping on achievement and classroom behavior among African American children. *Psychology in the Schools* 45, 8 (2008), 763–777.

[44] Joanne Gikas and Michael M. Grant. 2013. Mobile computing devices in higher education: Student perspectives on learning with cellphones, smartphones & social media. *The Internet and Higher Education* 19 (2013), 18–26. DOI: http://dx.doi.org/10.1016/j.iheduc.2013.06.002

[45] Miles Gilliom, Daniel S. Shaw, Joy E. Beck, Michael A. Schonberg, and Joella L. Lukon. 2002. Anger regulation in disadvantaged preschool boys: strategies, antecedents, and the development of self-control. *Developmental psychology* 38, 2 (2002), 222–235. DOI: http://dx.doi.org/10.1037/0012-1649.38.2.222

[46] Janet Go, Rafael Ballagas, and Mirjana Spasojevic. 2012. Brothers and sisters at play: exploring game play with siblings. In *Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work*. ACM, 739–748.

[47] John M. Gottman, Lynn Fainsilber Katz, and Carole Hooven. 1996. Parental meta-emotion philosophy and the emotional life of families: Theoretical models and preliminary data. *Journal of Family Psychology* 10, 3 (1996), 243–268. DOI: http://dx.doi.org/10.1037//0893-3200.10.3.243

[48] John Mordechai Gottman, Lynn Fainsilber Katz, and Carole Hooven. 1997. *Meta-emotion: How families communicate emotionally*. Psychology Press.

[49] Leslie S Greenberg. 2002. *Emotion-focused therapy: Coaching clients to work through their feelings*. APA, Washington.

[50] Mark T Greenberg. 2006. Promoting resilience in children and youth: preventive interventions and their interface with neuroscience. *Annals of the New York Academy of Sciences* 1094 (dec 2006), 139–50. DOI: http://dx.doi.org/10.1196/annals.1376.013

[51] James J. Gross. 2015. Emotion Regulation: Current Status and Future Prospects. *Psychological Inquiry* 26, 1 (2015), 1–26. DOI: http://dx.doi.org/10.1080/1047840X.2014.940781

[52] Daniel a. Hackman, Martha J. Farah, and Michael J. Meaney. 2010. Socioeconomic status and the brain: mechanistic insights from human and animal research. *Nature Reviews Neuroscience* 11, 9 (2010), 651–659. DOI: http://dx.doi.org/10.1038/nrn2897

[53] James J Heckman. 2006. Skill formation and the economics of investing in disadvantaged children. *Science (New York, N.Y.)* 312, 5782 (2006), 1900–1902. DOI: http://dx.doi.org/10.1126/science.1128898

[54] Jan Herrington. 2000. An Instructional Design Framework for Authentic Learning Environments. *Educational Technology Research and Development* 48 (2000), 23–48. DOI: http://dx.doi.org/10.1007/BF02319856

[55] Jan Herrington, Thomas C. Reeves, and Ron Oliver. 2014. Authentic Learning Environments. In *Handbook of Research on Educational Communications and Technology*. Springer New York, New York, NY, 401–412. DOI: http://dx.doi.org/10.1007/978-1-4614-3185-5_32

[56] Michael S. Horn, R. Jordan Crouser, and Marina U. Bers. 2012. Tangible interaction and learning: The case for a hybrid approach. *Personal and Ubiquitous Computing* 16, 4 (2012), 379–389. DOI: http://dx.doi.org/10.1007/s00779-011-0404-2

[57] Seth E. Hunter, Pattie Maes, Anthony Tang, Kori M. Inkpen, and Susan M. Hessey. 2014. WaaZam! Supporting Creative Play at a Distance in Customized Video Environments. In *CHI '14*. ACM Press, 1197–1206. DOI: http://dx.doi.org/10.1145/2556288.2557382

[58] Inseok Hwang, Chungkuk Yoo, Chanyou Hwang, Dongsun Yim, Youngki Lee, Chulhong Min, John Kim, and Junehwa Song. 2014. TalkBetter: family-driven mobile intervention care for children with language delay. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*. ACM, 1283–1296.

[59] Naomi Iga, Asuka Wakao, Kohei Matsumura, Roberto Lopez-Gulliver, and Haruo Noma. 2017. Improving Relationships between Parents and Children in Shopping Malls by Using a Digital Treasure Hunting Game. In *Extended Abstracts Publication of the Annual Symposium on Computer-Human Interaction in Play*. ACM, 261–267.

[60] Kaoru Inoue, Kazuyoshi Wada, and Reona Uehara. 2011. How effective is robot therapy?: Paro and people with dementia. In *5th European Conference of the International Federation for Medical and Biological Engineering*. Springer, 784–787.

[61] Katherine Isbister. 2016. *How Games Move Us: Emotion by Design*. MIT Press.

[62] Katherine Isbister, Kaho Abe, and Michael Karlesky. 2017. Interdependent wearables (for play): A strong concept for design. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 465–471.

[63] Katherine Isbister, Elena Márquez Segura, Suzanne Kirkpatrick, Xiaofeng Chen, Syed Salahuddin, Gang Cao, and Raybit Tang. 2016. Yamove! a movement synchrony game that choreographs social interaction. *Human Technology* 12 (2016).

[64] Katherine Isbister and Florian Floyd Mueller. 2015. Guidelines for the Design of Movement-Based Games and Their Relevance to HCI. *Human–Computer Interaction* 30, 3-4 (may 2015), 366–399. DOI: http://dx.doi.org/10.1080/07370024.2014.996647

[65] Madeleine Jaffe, Eleonora Gullone, and Elizabeth K. Hughes. 2010. The roles of temperamental dispositions and perceived parenting behaviours in the use of two emotion regulation strategies in late childhood. *Journal of Applied Developmental Psychology* 31, 1 (2010), 47–59. DOI: http://dx.doi.org/10.1016/j.appdev.2009.07.008

[66] Oliver P John and James J Gross. 2004. Healthy and unhealthy emotion regulation: Personality processes, individual differences, and life span development. *Journal of personality* 72, 6 (2004), 1301–1334.

[67] Rose Johnson, Venus Shum, Yvonne Rogers, and Nicolai Marquardt. 2016. Make or Shake: An Empirical Study of the Value of Making in Learning about Computing Technology. *Proceedings of the The 15th International Conference on Interaction Design and Children (IDC '16)* (2016), 440–451. DOI: http://dx.doi.org/10.1145/2930674.2930691

[68] Sheri L Johnson. 2005. Mania and dysregulation in goal pursuit: A review. *Clinical Psychology Review* 25, 2 (2005), 241–262.

[69] Jasmine Jones and David Merritt. 2017. KidKeeper : Design for Capturing Audio Mementos of Everyday Life for Parents of Young Children. (2017), 1864–1875.

[70] Stephanie M Jones and Suzanne M Bouffard. 2012. Social and Emotional Learning in Schools: From Programs to Strategies. Social Policy Report. Volume 26, Number 4. *Society for Research in Child Development* (2012).

[71] Tejinder K Judge and Carman Neustaedter. 2010. Sharing conversation and sharing life. In *CHI '10*. ACM Press, New York, USA, 655–658. DOI: http://dx.doi.org/10.1145/1753326.1753422

[72] Michael Karlesky and Katherine Isbister. 2016. Understanding Fidget Widgets : Exploring the Design Space of Embodied Self-Regulation. In *NordiCHI'16*. DOI: http://dx.doi.org/10.1145/2971485.2971557

[73] Lynn Fainsilber Katz and Erin C Hunter. 2007. Maternal meta-emotion philosophy and adolescent depressive symptomatology. *Social Development* 16, 2 (2007), 343–360.

[74] Jesper Kjeldskov, Martin R Gibbs, Frank Vetere, Steve Howard, Sonja Pedell, Karen Mecoles, and Marcus Bunyan. 2007. Using Cultural Probes to Explore Mediated Intimacy. *Australasian Journal of Information Systems* 11, 2 (2007).

[75] Elizabeth T. Kneeland, John F. Dovidio, Jutta Joormann, and Margaret S. Clark. 2016. Emotion malleability beliefs, emotion regulation, and psychopathology: Integrating affective and clinical science. *Clinical Psychology Review* 45 (2016), 81–88. DOI: http://dx.doi.org/10.1016/j.cpr.2016.03.008

[76] M. Knox, J. Lentini, T. S. Cummings, A. McGrady, K. Whearty, and L. Sancrant. 2011. Game-based biofeedback for paediatric anxiety and depression. *Mental Health in Family Medicine* 8, 3 (2011), 195–203.

[77] Claire B Kopp. 1992. Emotional distress and control in young children. *New Directions for Child and Adolescent Development* 1992, 55 (1992), 41–56.

[78] Ann M Kring and Jo-Anne Bachorowski. 1999. Emotions and psychopathology. *Cognition & Emotion* 13, 5 (1999), 575–599.

[79] J LeDoux. 1998. *The emotional brain: The mysterious underpinnings of emotional life*. Simon & Schuster.

[80] Iolanda Leite, Rui Henriques, Carlos Martinho, and Ana Paiva. 2013. Sensors in the wild: Exploring electrodermal activity in child-robot interaction. In *Human-Robot Interaction (HRI), 2013 8th ACM/IEEE International Conference on*. IEEE, 41–48.

[81] Marsha Linehan. 1993. *Cognitive-behavioral treatment of borderline personality disorder*. Guilford Press.

[82] Anna Loparev, Lauren Westendorf, Margaret Flemings, Jennifer Cho, Romie Littrell, Anja Scholze, and Orit Shaer. 2017. BacPack: Exploring the Role of Tangibles in a Museum Exhibit for Bio-Design. *Proceedings of the Tenth International Conference on Tangible, Embedded, and Embodied Interaction - TEI '17* (2017), 111–120. DOI: http://dx.doi.org/10.1145/3024969.3025000

[83] Erika S. Lunkenheimer, Ann M. Shields, and Kai S. Cortina. 2007. Parental emotion coaching and dismissing in family interaction. *Social Development* 16, 2 (2007), 232–248. DOI: http://dx.doi.org/10.1111/j.1467-9507.2007.00382.x

[84] Thomas R Lynch, William T Trost, Nicholas Salsman, and Marsha M Linehan. 2007. Dialectical behavior therapy for borderline personality disorder. *Annual Review of Clinical Psychology* 3 (2007), 181–205.

[85] Mar Pérez-Sanagustín, Pedro J. Muñoz-Merino, Carlos Alario-Hoyos, Xavier Soldani, and Carlos Delgado Kloos. 2015. Lessons learned from the design of situated learning environments to support collaborative knowledge construction. *Computers & Education* 87 (2015), 70–82. DOI: http://dx.doi.org/doi:10.1016/j.compedu.2015.03.019

[86] Paul Marshall. 2007. Do tangible interfaces enhance learning? (2007), 163. DOI: http://dx.doi.org/10.1145/1226969.1227004

[87] P Marti, A Pollini, A Rullo, and T Shibata. 2005. Engaging with artificial pets. In *Proceedings of the 2005 annual conference on European association of cognitive ergonomics*. University of Athens, 99–106.

[88] Florence Martin and Jeffrey Ertzberger. 2013. Here and now mobile learning: An experimental study on the use of mobile technology. *Computers and Education* 68 (2013), 76–85. DOI: http://dx.doi.org/10.1016/j.compedu.2013.04.021

[89] Sean McGlynn, Braeden Snook, Shawn Kemple, Tracy L. Mitzner, and Wendy A. Rogers. 2014. Therapeutic robots for older adults. *Proceedings of the 2014 ACM/IEEE international conference on Human-robot interaction - HRI '14* (2014), 246–247. DOI: http://dx.doi.org/10.1145/2559636.2559846

[90] Cor Meesters and Peter Muris. 2004. Perceived parental rearing behaviours and coping in young adolescents. *Personality and Individual Differences* 37, 3 (2004), 513–522.

[91] Douglas Mennin and Frank Farach. 2007. Emotion and evolving treatments for adult psychopathology. *Clinical Psychology: Science and Practice* 14, 4 (2007), 329–352.

[92] Mental Health Task Force to NHS England. 2016. Implementing the five year forward view for mental health. (2016), 82. https://www.england.nhs.uk/wp-content/uploads/2016/02/Mental-Health-Taskforce-FYFV-final.pdf

[93] Andrea Minuto and Anton Nijholt. 2013. Smart material interfaces as a methodology for interaction: a survey of SMIs' state of the art and development. In *Proceedings of the second international workshop on Smart material interfaces: another step to a material future*. ACM, 1–6.

[94] T. E. Moffitt, L. Arseneault, D. Belsky, N. Dickson, R. J. Hancox, H. Harrington, R. Houts, R. Poulton, B. W. Roberts, S. Ross, M. R. Sears, W. M. Thomson, and a. Caspi. 2011. A gradient of childhood self-control predicts health,

wealth, and public safety. *Proceedings of the National Academy of Sciences* 108, 7 (2011), 2693–2698. DOI: http://dx.doi.org/10.1073/pnas.1010076108

[95] Amanda Sheffield Morris, Jennifer S Silk, Laurence Steinberg, Sonya S. Myers, and Lara Rachel Robinson. 2007. The Role of the Family Context in the Development of Emotion Regulation. *Social Development* 16, 2 (2007), 361–388. DOI: http://dx.doi.org/10.1111/j.1467-9507.2007.00389.x.The

[96] Wendy Moyle, Marie Cooke, Elizabeth Beattie, Cindy Jones, Barbara Klein, Glenda Cook, and Chrystal Gray. 2013. Exploring the effect of companion robots on emotional expression in older adults with dementia: A pilot randomized controlled trial. *Journal of gerontological nursing* (2013).

[97] M.Reddy, P.Pratt, P.Dourish, and M.Shabot. 2003. Sociotechnical Requirements Analysis for Clinical System. *Methods Inf Med* 42 (2003), 437–444. DOI: http://dx.doi.org/10.1267/meth03040437

[98] Peter Muennig, Lawrence Schweinhart, Jeanne Montie, and Matthew Neidell. 2009. Effects of a prekindergarten educational intervention on adult health: 37-year follow-up results of a randomized controlled trial. *American journal of public health* 99, 8 (aug 2009), 1431–7. DOI: http://dx.doi.org/10.2105/AJPH.2008.148353

[99] National Institute for Health and Clinical Excellence. 2008. Social and emotional wellbeing in primary education [PH12]. *NICE Public Health Guidance* 12 (2008). http://guidance.nice.org.uk/PH12

[100] Janelle Nimer and Brad Lundahl. 2007. Animal-assisted therapy: A meta-analysis. *Anthrozoös* 20, 3 (2007), 225–238.

[101] Kimberly G. Noble, Bruce D. McCandliss, and Martha J. Farah. 2007. Socioeconomic gradients predict individual differences in neurocognitive abilities. *Developmental Science* 10, 4 (jul 2007), 464–480. DOI: http://dx.doi.org/10.1111/j.1467-7687.2007.00600.x

[102] Susan Nolen-Hoeksema, Blair E Wisco, and Sonja Lyubomirsky. 2008. Rethinking rumination. *Perspectives on psychological science* 3, 5 (2008), 400–424.

[103] Christoph Obermair, Wolfgang Reitberger, Alexander Meschtscherjakov, Michael Lankes, and Manfred Tscheligi. 2008. perFrames: Persuasive picture frames for proper posture. *Persuasive Technology* (2008), 128–139. DOI: http://dx.doi.org/10.1007/978-3-540-68504-3_12

[104] OECD. 2015. *Skills for Social Progress.* Technical Report January. 24–25 pages. DOI: http://dx.doi.org/10.1787/9789264226159-en

[105] Marguerite E O'Haire. 2013. Animal-assisted intervention for autism spectrum disorder: A systematic literature review. *Journal of autism and developmental disorders* 43, 7 (2013), 1606–1622.

[106] T. E. O'Shaughnessy, K. L. Lane, F. M. Gresham, and M. E. Beebe-Frankenberger. 2003. Children Placed at Risk for Learning and Behavioral Difficulties: Implementing a School-Wide System of Early Identification and Intervention. *Remedial and Special Education* 24, 1 (jan 2003), 27–35. DOI: http://dx.doi.org/10.1177/074193250302400103

[107] Sanela Osmanovic and Loretta Pecchioni. 2016. Beyond entertainment: motivations and outcomes of video game playing by older adults and their younger family members. *Games and Culture* 11, 1-2 (2016), 130–149.

[108] David Parsons. 2014. A Mobile Learning Overview by Timeline and Mind Map. *International Journal of Mobile and Blended Learning* 6, 4 (2014), 1–20. DOI: http://dx.doi.org/10.4018/ijmbl.2014100101

[109] Evanthia N Patrikakou, Roger P. Weissberg, Sam Redding, and Herbert J. Wahlberg (Eds.). 2005. *School-family partnerships for children's success.* Teachers College Press.

[110] D. Paunesku, G. M. Walton, C. Romero, E. N. Smith, D. S. Yeager, and C. S. Dweck. 2015. Mind-Set Interventions Are a Scalable Treatment for Academic Underachievement. *Psychological Science* (2015). DOI: http://dx.doi.org/10.1177/0956797615571017

[111] Laura Pina, Kael Rowan, Asta Roseway, Paul Johns, Gillian R Hayes, and Mary Czerwinski. 2014. In Situ Cues for ADHD Parenting Strategies Using Mobile Technology. In *Pervasive Health '14.*

[112] Sara Price and Yvonne Rogers. 2004. Let's get physical: The learning benefits of interacting in digitally augmented physical spaces. *Computers and Education* 43, 1-2 SPEC ISS. (2004), 137–151. DOI: http://dx.doi.org/10.1016/j.compedu.2003.12.009

[113] Hayes Raffle, Mirjana Spasojevic, Rafael Ballagas, Glenda Revelle, Hiroshi Horii, Sean Follmer, Janet Go, Emily Reardon, Koichi Mori, and Joseph Kaye. 2010. Family story play: reading with young children (and elmo) over a distance. In *CHI '10.* ACM Press, 1583. DOI: http://dx.doi.org/10.1145/1753326.1753563

[114] Sally R Ramsden and Julie A Hubbard. 2002. Family expressiveness and parental emotion coaching: Their role in children's emotion regulation and aggression. *Journal of abnormal child psychology* 30, 6 (2002), 657–667.

[115] M Jamila Reid, Carolyn Webster-Stratton, and Mary Hammond. 2007a. Enhancing a classroom social competence and problem-solving curriculum by offering parent training to families of moderate-to high-risk elementary school children. *Journal of Clinical Child and Adolescent Psychology* 36, 4 (2007), 605–620.

[116] M Jamila Reid, Carolyn Webster-Stratton, and Mary Hammond. 2007b. Enhancing a classroom social competence and problem-solving curriculum by offering parent training to families of moderate-to high-risk elementary school children. *Journal of Clinical Child and Adolescent Psychology* 36, 4 (2007), 605–620.

[117] Maria Regina Reyes, Marc A. Brackett, Susan E. Rivers, Nicole A. Elbertson, and Peter Salovey. 2012. The Interaction Effects of Program Training, Dosage, and Implementation Quality on Targeted Student Outcomes for The RULER Approach to Social and Emotional Learning. *School Psychology Review* 41, 1 (2012), 82–99. http://www.eric.ed.gov/ERICWebPortal/search/detailmini.jsp?

[118] Hayley Robinson, Bruce MacDonald, Ngaire Kerse, and Elizabeth Broadbent. 2013. The psychosocial effects of a companion robot: a randomized controlled trial. *Journal of the American Medical Directors Association* 14, 9 (2013), 661–667.

[119] Yvonne Rogers, Sara Price, Geraldine Fitzpatrick, Rowanne Fleck, Eric Harris, Hilary Smith, Cliff Randell, Henk Muller, Claire O'Malley, Danae Stanton, and Others. 2004. Ambient wood: designing new forms of digital augmentation for learning outdoors. In *Proceedings of the 2004 conference on Interaction design and children: building a community*. ACM, 3–10.

[120] Carissa Romero, Allison Master, Dave Paunesku, Carol S Dweck, and James J Gross. 2014. Academic and emotional functioning in middle school: the role of implicit theories. *Emotion* 14, 2 (2014), 227–34. DOI: http://dx.doi.org/10.1037/a0035490

[121] Jonathan Rottenberg, James J Gross, and Ian H Gotlib. 2005. Emotion Context Insensitivity in Major Depressive Disorder. *Journal of Abnormal Psychology* 114, 4 (2005), 627–639.

[122] Herman Saksono, Ashwini Ranade, Geeta Kamarthi, Carmen Castaneda-Sceppa, Jessica A Hoffman, Cathy Wirth, and Andrea G Parker. 2015. Spaceship Launch: Designing a Collaborative Exergame for Families. In *CSCW '15*. 1776–1787. DOI: http://dx.doi.org/10.1145/2675133.2675159

[123] Katie Salen and Eric Zimmerman. 2004. *Rules of play: Game design fundamentals*. MIT press.

[124] Elke A. Schoneveld, Monique Malmberg, Anna Lichtwarck-Aschoff, Geert P. Verheijen, Rutger C.M.E. Engels, and Isabela Granic. 2016. A neurofeedback video game (MindLight) to prevent anxiety in children: A randomized controlled trial. *Computers in Human Behavior* 63 (2016), 321–333. DOI: http://dx.doi.org/10.1016/j.chb.2016.05.005

[125] Elena Márquez Segura and Katherine Isbister. 2015. Game User Experience Evaluation. (2015), 209–238. DOI: http://dx.doi.org/10.1007/978-3-319-15985-0

[126] Daniel S Shaw and Elizabeth C Shelleby. 2014. Early-starting conduct problems: intersection of conduct problems and poverty. *Annual review of clinical psychology* 10 (2014), 503–28. DOI: http://dx.doi.org/10.1146/annurev-clinpsy-032813-153650

[127] Gal Sheppes, Jens Blechert, and James J Gross. 2014. Emotion Regulation Choice : A Conceptual Framework and Supporting Evidence. 143, 1 (2014).

[128] Kimberly L Shipman, Renee Schneider, Monica M Fitzgerald, Chandler Sims, Lisa Swisher, and Anna Edwards. 2007. Maternal emotion socialization in maltreating and non-maltreating families: Implications for children's emotion regulation. *Social Development* 16, 2 (2007), 268–285.

[129] Elaine Short, Katelyn Swift-Spong, Jillian Greczek, Aditi Ramachandran, Alexandru Litoiu, Elena Corina Grigore, David Feil-Seifer, Samuel Shuster, Jin Joo Lee, Shaobo Huang, Svetlana Levonisova, Sarah Litz, Jamy Li, Gisele Ragusa, Donna Spruijt-Metz, Maja Mataric, and Brian Scassellati. 2014. How to train your DragonBot: Socially assistive robots for teaching children about nutrition through play. *IEEE RO-MAN 2014 - 23rd IEEE International Symposium on Robot and Human Interactive Communication: Human-Robot Co-Existence: Adaptive Interfaces and Systems for Daily Life, Therapy, Assistance and Socially Engaging Interactions* (2014), 924–929. DOI: http://dx.doi.org/10.1109/ROMAN.2014.6926371

[130] Petr Slovák and Geraldine Fitzpatrick. 2015. Teaching and developing social and emotional skills with technology. *ACM Transactions on Computer-Human Interaction (TOCHI)* 22, 4 (2015), 19.

[131] Petr Slovak, Chris Frauenberger, and Geraldine Fitzpatrick. 2017. Reflective Practicum: A Framework of Sensitising Concepts to Design for Transformative Reflection. In *CHI'17*. ACM, 2696–2707. DOI: http://dx.doi.org/10.1145/3025453.3025516

[132] Petr Slovák, Christopher Frauenberger, Ran Gilad-Bachrach, Mia Doces, Brian Smith, Rachel Kamb, Kael Rowan, and Geraldine Fitzpatrick. 2016. Scaffolding the scaffolding: Supporting children-s social-emotional learning at home. In *CSCW '16*. ACM Press, 1749–1763. DOI: http://dx.doi.org/10.1145/2818048.2820007

[133] Petr Slovák, Ran Gilad-Bachrach, and Geraldine Fitzpatrick. 2015. Designing Social and Emotional Skills Training. In *CHI '15*. ACM, 2797–2800. DOI: http://dx.doi.org/10.1145/2702123.2702385

[134] Ian Sommerville and Guy Dewsbury. 2007. Dependable domestic systems design: A socio-technical approach. *Interacting with Computers* 19, 4 (2007), 438–456. DOI: http://dx.doi.org/10.1016/j.intcom.2007.05.002

[135] Seokwoo Song, Seungho Kim, John Kim, Wonjeong Park, and Dongsun Yim. 2016. TalkLIME : Mobile System Intervention to Improve Parent-Child Interaction for Children with Language Delay. (2016), 304–315.

[136] Megan A Souter and Michelle D Miller. 2007. Do animal-assisted activities effectively treat depression? A meta-analysis. *Anthrozoös* 20, 2 (2007), 167–180.

[137] Abigale Stangl, Joanna Weidler-lewis, Carlye Lauff, Emily Price, and Eric Fauble. 2017. The SEL Transition Wheel : Designing for Early Childhood Social Emotional Learning. In *IDC'17*. 334–339.

[138] Yingze Sun, Matthew P. Aylett, and Yolanda Vazquez-Alvarez. 2016. e-Seesaw: A Tangible, Ludic, Parent-child, Awareness System. *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA '16* (2016), 1821–1827. DOI: http://dx.doi.org/10.1145/2851581.2892349

[139] R. C. Teepe, I. Molenaar, and L. Verhoeven. 2017. Technology-enhanced storytelling stimulating parent–child interaction and preschool children's vocabulary knowledge. *Journal of Computer Assisted Learning* 33, 2 (2017), 123–136. DOI: http://dx.doi.org/10.1111/jcal.12169

[140] Ross A Thompson and Sara Meyer. 2007. Socialization of emotion regulation in the family. In *Handbook of Emotion Regulationmotion regulation*, James J. Gross (Ed.). Guilford Press, New York, 249–268.

[141] Sherry Turkle. 2005. Relational Artifacts/Children/Elders: The Complexities of CyberCompanions. *Cognitive Science Society* (2005), 6273. DOI: http://dx.doi.org/10.1080/09540090600868912

[142] Sherry Turkle. 2007. Authenticity in the age of digital companions. *Interaction Studies* 8, 3 (2007), 501–517. DOI: http://dx.doi.org/10.1075/is.8.3.11tur

[143] Sherry Turkle. 2017. *Alone together: Why we expect more from technology and less from each other.* Hachette UK.

[144] Karen Vanderloock, Vero Vanden Abeele, Johan A K Suykens, and Luc Geurts. 2013. The skweezee system: enabling the design and the programming of squeeze interactions. In *Proceedings of the 26th annual ACM symposium on User interface software and technology*. ACM, 521–530.

[145] Svetha Venkatesh, Dinh Phung, Thi Duong, Stewart Greenhill, and Brett Adams. 2013. TOBY: early intervention in autism through technology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 3187–3196.

[146] Dhaval Vyas, Wim Poelman, Anton Nijholt, and Arnout De Bruijn. 2012. Smart material interfaces: a new form of physical interaction. In *CHI'12 Extended Abstracts on Human Factors in Computing Systems*. ACM, 1721–1726.

[147] Kazuyoshi Wada, Yousuke Ikeda, Kaoru Inoue, and Reona Uehara. 2010. Development and preliminary evaluation of a caregiver's manual for robot therapy using the therapeutic seal robot Paro. In *RO-MAN, 2010 IEEE*. IEEE, 533–538.

[148] Gregory M Walton. 2014. The New Science of Wise Psychological Interventions. *Current Directions in Psychological Science* 23, 1 (2014), 73–82. DOI: http://dx.doi.org/10.1177/0963721413512856

[149] K. Weare and M. Nind. 2011. Mental health promotion and problem prevention in schools: what does the evidence say? *Health Promotion International* 26, S1 (nov 2011), i29–i69. DOI: http://dx.doi.org/10.1093/heapro/dar075

[150] C Webster-Stratton and M Hammond. 1997. Treating children with early-onset conduct problems: a comparison of child and parent training interventions. *Journal of consulting and clinical psychology* 65, 1 (1997), 93–109. DOI: http://dx.doi.org/10.1037/0022-006X.65.1.93

[151] Natalie Wood, Amanda Sharkey, and Gail Mountain3and Abigail Millings. 2015. The Paro robot seal as a social mediator for healthy users. *New Frontiers in Human-Robot Interaction* (2015), 109. https://www.cs.kent.ac.uk/events/2015/AISB2015/proceedings/hri/4-Wood-theparorobot.pdf

[152] Til Wykes, Josep Maria Haro, Stefano R. Belli, Carla Obradors-Tarragó, Celso Arango, José Luis Ayuso-Mateos, István Bitter, Matthias Brunn, Karine Chevreul, Jacques Demotes-Mainard, Iman Elfeddali, Sara Evans-Lacko, Andrea Fiorillo, Anna K. Forsman, Jean Baptiste Hazo, Rebecca Kuepper, Susanne Knappe, Marion Leboyer, Shôn W. Lewis, Donald Linszen, Mario Luciano, Mario Maj, David McDaid, Marta Miret, Szilvia Papp, A. La Park, Gunter Schumann, Graham Thornicroft, Christina van der Feltz-Cornelis, Jim van Os, Kristian Wahlbeck, Tom Walker-Tilley, and Hans Ulrich Wittchen. 2015. Mental health research priorities for Europe. *The Lancet Psychiatry* 2, 11 (2015), 1036–1042. DOI: http://dx.doi.org/10.1016/S2215-0366(15)00332-6

[153] Peter a Wyman, Wendi Cross, C Hendricks Brown, Qin Yu, Xin Tu, and Shirley Eberly. 2010. Intervention to strengthen emotional self-regulation in children with emerging mental health problems: proximal impact on school behavior. *Journal of abnormal child psychology* 38, 5 (jul 2010), 707–20. DOI: http://dx.doi.org/10.1007/s10802-010-9398-x

[154] Lu Xiao and Jennifer Martin. 2012. Supporting parent-young child activities with interactive tabletops: a conceptual analysis. In *CSCW'12 Companion*. 301–310. DOI: http://dx.doi.org/10.1145/2141512.2141606

[155] Svetlana Yarosh. 2008. Supporting Long-Distance Parent-Child Interaction in Divorced Families. In *IDC'08*. 3795–3800.

[156] Sangseok Yun, Jongju Shin, Daijin Kim, Chang Gu Kim, Munsang Kim, and Mun-Taek Choi. 2011. Engkey: Tele-education robot. In *International Conference on Social Robotics*. Springer, 142–152.

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